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STATUS AND TRENDS IN WATER QUALITY AND LIVING RESOURCES IN THE VIRGINIA CHESAPEAKE BAY: JAMES RIVER (1985-2001)

Prepared by

Principal Investigators:

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Submitted to:

Mr. Frederick J. Hoffman
Virginia Department of Environmental Quality
629 East Main Street
Richmond, Virginia 23230

February 24, 2003

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Notice

During the mid-1990's the Chesapeake Bay Program's (CBP) Analytical Methods and Quality Assurance Workgroup recommended that the CBP adopt new and more accurate analytical methods for measuring total nitrogen, dissolved inorganic nitrogen, total phosphorus and dissolved inorganic phosphorus. An recent examination of scatterplots of these parameters suggested that the adoption of these news methods in 1994 may have resulted in step trends in concentrations of these parameters. Since the presence of a step trend in the data would adversely affect the ability to detect long-term trends, the CBP's Tidal Monitoring and Assessment Workgroup (TMAW) recommended a statistical protocol that could be used to identify and correct step trends caused by the method changes in these parameters. This procedure would serve as a "stop-gap" protocol until more robust statistical techniques could be developed and adopted for general use by the CBP for long term-trend detection in such cases.

This report presents long-term trend results on nutrient data using TMAW's "stop-gap" protocol (see in Chapter III). Subsequent examinations of the results of these analyses by the TMAW indicate that, in some cases, the method correction protocols may not have performed with the desired validity. As a result, caution should be used in interpreting the long-term water quality trends conducted on the method-corrected nutrient data provided in this report.

Results for dissolved inorganic nitrogen in tidal fresh and oligohaline segments indicated there were no method change effects (see Table 3-1:Chapter III) and, as a result, long-term trend analyses performed on these parameters within these salinity regimes should be valid. In addition, all long term trends (1985 to 2001) presented for chlorophyll *a*, total suspended solids, secchi depth, dissolved oxygen, salinity and temperature were not subjected to method correction protocols and can be considered valid. All trends presented on data collected from 1995 through 2001 are valid. A new method for assessing long term trends on data subjected to analytical method changes will be used in all subsequent reports.

Preface

This material in this report was produced for the Virginia Department of Environmental Qaulity in order to summarize patterns of status and trends in water quality, phytoplankton, primary productivity, zooplankton and benthos collected as part of the Virginia Chesapeake Bay Program. There are three reports, referred to as basin summaries, one each for the James River, the York River and the Rappahannock River. These basin summaries are intended to be electronic reports that will be periodically updated and they were intended for an audience already knowledgeable of the history and rationale of the program; design of the program; field and laboratory methods; specialized parameters, e.g. the Benthic Index of Biotic Integrity; status and trends analytical methods, etc.

In order to create a record of past patterns in status and trends and to make these data more widely available, a printed version of each basin summary was produced. To make the information more interpretable we have added an introduction and a methods section. However, this report is a data report and is not a comprehensive, interpretive report. Therefore, there is no discussion section to this report.

All three basin summaries and appendices are available at the Old Dominion University Chesapeake Bay Program website <www.chesapeakebay.odu.edu> under "Reports." The James River Report includes the Elizabeth River, the Chickahominy River and the Appomattox River. The York River Report includes the tidal Pamunkey River and Mattaponi River. The Rappahannock River Report includes the Corrotoman River. Also available at this website are appendices that include (1) tables of status for all parameters measured at all stations sampled by each program, (2) tables of all parameters and metrics for which there was a significant trend, and (3) scatter plots of all parameters over time. There are five appendices: water quality, phytoplankton, primary productivity, zooplankton and benthos.

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Summary

This summary includes materials provided by Rick Hoffman of the Chesapeake Bay Program of the Virginia Department of Environmental Quality. Environmental information regarding other important conditions in Chesapeake Bay (e.g. submerged aquatic vegetation, fisheries, chemical contaminants) has been reported previously (*Chesapeake Bay and its Tributaries: Results of Monitoring Programs And Status of Resources; 2002 Biennial Report of the Secretary of Natural Resources to The Virginia General Assembly*).

The Virginia Chesapeake Bay and its tidal tributaries continue to show some environmental trends indicating progress toward restoration of a more balanced and healthy ecosystem. However, the Bay system remains degraded and some areas and indicators show continuing degradation. Progress in reducing nutrient inputs has made demonstrable improvements and we expect that continued progress toward nutrient reduction goals, along with appropriate fisheries management and chemical contaminant controls, will result in additional improvements to the Bay. Findings from the last 17 years of the monitoring programs are highlighted below. Patterns of nutrient and sediment loads are summarized in Table 1.

- Nonpoint source loads (estimates of controllable and uncontrollable) of phosphorus, nitrogen, and sediment as calculated by the Bay Program Watershed Model, decreased by 7%, 9%, and 11%, respectively, compared to the 1985 baseline loads.

- Point source nutrient loads were reduced by 57% for phosphorus and 25% for nitrogen, compared to the 1985 baseline loads. This decrease in discharge may be partly due to ongoing drought conditions in Virginia.

- Combined nutrient loads were reduced by 26% for phosphorus and 15% for nitrogen, compared to the 1985 baseline loads.

- For phosphorus, there were improving trends at the river input stations of the James River, Mattaponi River and Rapphannock River with a degrading trend in the Pamunkey River. The improving trends are indicative of both point and nonpoint source nutrient reductions over the last 17 years. Although some improving trends were detected in tidal waters, many degrading trends in phosphorus were detected. Overall, there were 12 areas with improving trends and 19 areas with degrading trends in this parameter.

- For nitrogen, there were improving trends in the Mattaponi River and the Potomac River and a degrading trend in the Pamunkey River. Nitrogen levels showed improving trends in much of the tidal Potomac River and Elizabeth River. Degrading trends occurred in much of the tidal York River and lower James River. Overall, there were 9 areas showing improving trends and 10 areas showing degrading trends for nitrogen.

- Because of improvements made in analytical techniques instituted in 1995, a second set of trend analyses on data from 1995 through the present were preformed in order to use the most consistent data record. Both phosphorus and nitrogen show many improving conditions throughout the Virginia Chesapeake Bay when these most recent seven years are examined. These improvements are probably related to the management actions to reduce nutrient inputs as well as the generally decreased river flow that has occurred in recent years.

- Chlorophyll levels are moderately high throughout much of the tidal waters. Degrading trends were widespread geographically and indicative of detrimentally high nutrient levels. Overall, nine areas showed degrading trends in chlorophyll *a* while only one area showed an improving trend.

- Levels of dissolved oxygen are improving in geographically widespread areas of the tidal rivers. However, conditions for dissolved oxygen still remain only fair in much of the Virginia Chesapeake Bay and a few of the river segments near the Bay. The Corrotoman River and Tangier Sound are the only areas with degrading trends in dissolved oxygen. Overall, there were 13 areas showing improving trends and two areas showing degrading trends for dissolved oxygen conditions.

- Water clarity, a very important environmental parameter, was generally poor and degrading trends were detected in many areas near and in the Virginia Chesapeake Bay. This is probably related to high and scattered increasing levels of suspended solids. These degrading conditions in the Virginia Chesapeake Bay may result in degradation of zooplankton populations and are a major impediment to restoration of submerged aquatic vegetation (SAV). Overall, there were no areas showing improving trends and 13 areas showing degrading trends in water clarity.

- With regard to algal levels, there are widespread increases in cyanobacterial abundance and biomass and also concern about the poor status of dinoflagellates. However, there are widespread improvements in rates of primary productivity.

- Zooplankton community diversity showed generally improving trends in upstream regions but degrading trends at the mouths of all three rivers. These degrading trends are possibly related to degrading trends in nitrogen, phosphorus, and water clarity indicators, and a decreasing trend in salinity.

- Benthic community patterns differed greatly between the rivers. In the James River there strong improving trends upstream and continued good status down stream. In the Elizabeth River there was a strong improving trend although the status of the benthic communities remains poor. In the York River and the Rappahannock River there are degrading trends in the middle reaches.

Table 1. Nutrient and Sediment Loads for Virginia (2001). Modified from data provided by the Virginia Department of Environmental Quality. Phosphorous and nitrogen loads are in kg/year and sediment loads are metric tons/year. Percent change compares 2001 data to 1985 data. Nonpoint source loads are results based on the Year 2000 Progress Run of Phase 4.3 of the Chesapeake Bay Watershed Model and calculated reductions for calendar year 2001 Best Management Practices (BMPs) as monitored by the Department of Conservation and Recreation.

River Basin	2001 Phosphorus Load	Percent Change in Phosphorus	2001 Nitrogen Load	Percent Change in Nitrogen	2001 Sediment Load	Percent Change in Sediment
A. Nonpoint Loads						
Potomac	749,527	-10.5%	6,305,959	-10.1%	650,655	-13.4%
Rappahannock	396,532	-19.5%	3,372,686	-19.9%	297,812	-21.4%
York	297,250	-13.4%	3,089,427	-13.3%	126,172	-12.2%
James	2,037,523	- 0.8%	10,316,677	- 2.7%	1,085,925	- 5.4%
Coastal	88,295	-14.2%	943,327	- 5.0%	17,581	-17.2%
Totals	3,569,127	- 7%	24,028,077	- 9%	2,178,145	-11%
B. Point Source Loads. In parentheses is the number of significant point source discharges.						
Potomac (40)	251,218	-28%	5,336,045	+8%		
Rappahannock (14)	21,850	-74%	247,132	+11%		
York (9)	83,000	-59%	501,573	-20%		
James (30)	619,655	-62%	6,138,200	-44%		
Coastal (8)	66,482	-56%	826,527	+40%		
Totals	1,042,205	-57%	13,049,477	-25%		
C. Total Loads. All river basins combined.						
Nonpoint Source	3,569,127	-7%	24,028,077	-9%	2,178,145	-10.8%
Point Source	1,042,205	-57%	13,049,477	-25%		
Combined Loads	4,611,332	-26%	37,077,555	-15%	2,178,145	-10.8%

Chapter 1. Introduction

A marked decline in the water quality of the Chesapeake Bay has occurred over the past several decades. The disappearance of submerged aquatic vegetation in certain regions of the Bay, declines in the abundance of some commercially and recreationally important species, increases in the incidence of low dissolved oxygen events, changes in the Bay's food web, and other ecological problems have been related to the deteriorating water quality. The results of concentrated research efforts in the late 1970s and early 1980s stimulated the establishment of Federal and state directives to better manage the Chesapeake Bay watershed. By way of the Chesapeake Bay Agreements of 1983, the State of Maryland, the Commonwealths of Virginia and Pennsylvania, and the District of Columbia, agreed to share the responsibility for improving environmental conditions in the Chesapeake Bay. As part of this agreement, a long-term monitoring program in the Chesapeake Bay was established in order to: 1) track long-term trends in water quality and living resource conditions over time, 2) assess current water quality and living resource conditions, and 3) establish linkages between water quality and living resources communities. By tracking long-term trends in water quality and living resources, managers may be able to determine if changes in water quality and living resource conditions have occurred over time and if those changes are a reflection of management actions. Assessments of current status may allow managers to identify regions of concern that could benefit from the implementation of pollution abatement or management strategies. By identifying linkages between water quality and living resources it may be possible for managers to determine the impact of water quality management practices on living resource communities.

Water quality and living resource monitoring in the Virginia Mainstem and tributaries began in 1985 and has continued for 16 years. Detailed assessments of the status and long-term trends in water quality and living resources in Chesapeake Bay and its tributaries have been previously conducted (Alden et al., 1991,1992; Carpenter and Lane, 1998; Dauer, 1997; Dauer et al., 1998a,1998b, 2002; Lane et al.,1998; Marshall, 1994,1996; Marshall and Burchardt, 1998; Marshall et al., 1998). An attempt was made to determine if there was concordance in current conditions of, and long-term changes, in water quality and living resources. The purpose of this project was to reassess the results of these studies by re-conducting the analyses after adding data collected during 2001. This report describes the status of water quality and living resource conditions for the Virginia Mainstem and tributaries, summarizes major long-term trends in water quality and measures of living resource community health.

Chapter 2. Monitoring Program Descriptions

I. Water Quality

A. Sampling Locations and Procedures

As part of the U. S. Geological Survey's River Input Program, water quality data have been collected at five stations near the fall line and three stations above the fall line in Virginia. Samples were taken at base-flow twice a month and during high flows whenever possible between 1988 and 2001. Water quality data have also been collected by the Virginia Department of Environmental Quality at three additional stations upstream of these River Input sites (Figure 2-1). These stations had a minimum of three consecutive years of samples taken between 1985 and 1996 with sampling occurring on at least a monthly basis.

Water quality conditions were regularly monitored at 28 sites in the Bay Mainstem beginning in July, 1985. From 1985 until 1995 eight stations were sampled by Old Dominion University (ODU) and 20 stations were sampled by the Virginia Institute of Marine Science (VIMS). From 1995 through the present, Mainstem water quality monitoring was conducted by ODU. Tributary water quality monitoring was conducted by the Department of Environmental Quality at 28 sites in the James, York (including Mattaponi and Pamunkey) and Rappahannock rivers (Figure 2-2). In addition, six permanent water quality monitoring sites were established in the Elizabeth River/Hampton Roads Harbor by ODU in February, 1989 (Figure 2-2).

The temporal sampling scheme for the water quality monitoring program changed several times over the 14 year period (varying from 20 to 12 sampling events per year) as a result of changes in the monitoring program budget. In general, Mainstem sampling cruises were conducted semi-monthly from March through October and monthly from November through February. Tributary sampling by the Virginia Department of Environmental Quality was generally conducted 20 times per year. The Elizabeth River stations were sampled monthly. Field sampling procedures used for ODU and VIMS water quality collections are described in detail by Alden et al., 1992a. Field sampling procedures for DEQ water quality collections are described in detail in DEQ's Quality Assurance Project Plan for the Chesapeake Bay Program (Applied Marine Research Laboratory, 1998).

B. Laboratory sample processing

Descriptions of laboratory sample processing and standard operating procedures for all water quality parameters are found in the Chesapeake Bay Program Quality Assurance Project Plans (QAPjPs) prepared by each of the participating laboratories (Applied Marine Research Laboratory, 1998). Copies of the QAPjPs can be obtained by contacting EPA's Chesapeake Bay Program Quality Assurance Officer.

A. Sampling Locations and Procedures

Seven stations were established in Chesapeake Bay in July 1985. These were CB6.1, CB6.4, CB7.3E, CB7.4, LE5.5, WE4.2, and LE3.6 (Figure 2-3). From July, 1985 through September, 1990, phytoplankton collections were taken from these stations twice a month from March through October, and monthly November through February. From October, 1990, monthly samples were taken at all Bay stations. Monthly sample collections and analysis in the James (TF5.5, RET5.2), York (RET4.1, RET4.3), and Rappahannock (TF3.3, RET3.1) rivers began in March, 1986. In March, 1987, station RET4.1 in the Pamunkey River was replaced by station TF4.2, and in February, 1989, monthly collections began at two stations (SBE2, SBE5) in the Elizabeth River. Picoplankton analysis was included at several trial stations in January, 1989, and was expanded to include all stations in July, 1989. Primary production analysis was added to all Bay and tributary stations in July 1989.

At each station, two vertical sets of three liter water samples were taken at five equidistant depths above the pycnocline and placed in two separate carboys. The process was repeated at five depths below the pycnocline. The water in each carboy was carefully mixed and replicate 500 ml sub-samples were removed from each carboy, and fixed with Lugol's solution. A second set of 125 ml sub-samples were also taken above and below the pycnocline, preserved with glutaraldehyde and placed in a cooler. These samples were taken to determine the concentrations of the autotrophic picoplankton population. An additional replicate set was also taken from the same carboy set taken above the pycnocline for primary productivity measurements.

B. Laboratory Sample Processing

Samples for phytoplankton analyses were passed through a series of settling and siphoning steps to produce a concentrate (or fraction of the concentrate) that was examined using a modified Utermöhl method with an inverted plankton microscope (Marshall and Alden, 1990). The analysis procedure attained an estimated precision of 85% (Venrick, 1978). The autotrophic picoplankton were processed through a protocol that included their collection on a 0.2 µ nucleopore filter, with subsequent analysis using an epifluorescent microscope, under oil at 1000x magnification, with a "green" and “blue” filter sets (Marshall, 1995). Supplemental analysis with a scanning electron microscope was used in several of the species identifications. Methodology for the productivity measurements is given in Marshall and Nesius (1996). Appropriate quality assurance/quality control practices in sample collection, analysis, and data entry were employed throughout this period.

III. Zooplankton

A. Sampling Locations and Procedures

Microzooplankton communities were monitored monthly at seven sites in the Mainstem and six sites in the Virginia tributaries beginning in January, 1993 (Figure 3-3). Whole water samples were collected at all stations. Before sampling, 10 ml of modified Lugol's solution was placed into two liter (L) bottles designated for each station. The water was sampled through the use of a battery powered pump attached to a hose. Two composite water samples, each totaling 15 L, were taken from five equidistant depths above the pycnocline and collected in two carboys. Each carboy was thoroughly mixed and 1 L taken from each (Samples A and B for each station).

Mesozooplankton communities were monitored monthly at seven sites in the Mainstem beginning in July, 1985 (Figure 3-3). Monthly mesozooplankton monitoring was conducted at six sites in the major Virginia tributaries (Rappahannock, York/Pamunkey, and James rivers) beginning in March, 1986 (one site on the Pamunkey was originally sampled at RET4.1 but relocated to TF4.2 in February, 1987). In 1986 a new sampling regime began that increased frequency to two samples per month during April, May, July, and August at all the tidal freshwater stations (TF3.3, TF4.2, TF5.5). At the same time, sampling frequency was increased to twice per month for July and August also at stations RET3.1, RET4.3, RET5.2, LE5.5, and SBE5 in order to allow better characterization of zooplankton communities during spawning periods of commercially important fish species in these areas.

Single mesozooplankton tows were conducted at each site using a bongo apparatus with 202 µ mesh nets. The nets were towed obliquely from the surface to 1 m above the bottom and back to the surface over a period of approximately five minutes. A calibrated flowmeter was attached to each net and flowmeter readings were recorded just prior to net deployment and immediately upon net retrieval. Once onboard the research vessel, the nets were "washed down" and the contents of the cod-ends were decanted into pre-labeled one liter sample containers and preserved with 7% buffered formalin. All sample numbers were recorded on a sample chain-of-custody form before departing the site.

B. Laboratory Sample Processing

The whole water samples taken for microzooplankton (<200µ) analysis were processed through a screen, plus a series of settling and siphoning procedures (Park and Marshall, 1993). These steps removed the larger zooplankters and debris to provide 3 sub-sets based on size to be analyzed. This method insured the collection and analysis of the small non-loricated ciliates to be included in the count.

The mesozooplankton samples were processed according to the coefficient of variation stabilizing (CVS) method described by Alden et al. (1982). This method has numerous advantages over other zooplankton enumeration techniques. The CVS method provides abundance estimates with equitable coefficients of variation for species of interest in zooplankton subsamples. It is particularly useful in increasing the precision of the estimates of numbers of large species of relatively low abundance that may be important due to their biomass, their trophic position, or their economic significance. The investigator can be quite confident that the precision of the abundance estimates is at least at the pre-determined level for all species processed by the CVS method. The method also has the advantage of allowing the investigator to set a level of precision that is consistent with cost, manpower, or time constraints. Finally, the size class data produced by the CVS method may provide information of intrinsic ecological significance.

Briefly, the CVS method involves the sieve fractionation of the samples into size classes of 2000µ, 850µ, 650µ, 300µ, and 200µ. This series was found useful for Bay mesozooplankton communities. An additional sieve size fraction between 200µ and 63µ was collected and analyzed beginning in 1998. This fraction was added to allow greater comparability with the mesozooplankton data collected in Maryland. However, these data are incomplete and the results from this additional sieve-size fraction will be reported beginning with the 1999 data set. The size classes appropriate for whole counts were transferred to labeled vials containing 7% buffered formalin and temporarily stored until counted. The size class aliquots in which the organisms were too numerous to count in their entirety were split with a Folsom plankton splitter until an appropriate sample size was achieved for statistically valid counts of the dominant species. A level of sampling error of 30% requires that each species of interest be counted to achieve a range of between 30 and 56 organisms counted in any given split. During the splitting process, reserve splits were labeled, preserved in formalin and retained until the counting procedure was completed. Those species observed in the final split were counted in the reserved splits until all had achieved the range for the 30% error level (see Alden et al., 1982 for details of CVS methodology). However, if commercially important species (e.g., blue crab zoea) were encountered, they were counted to achieve the 30% error level for the statistical models. The samples were counted under a dissecting microscope in custom-designed counting trays (60 mm tissue culture dishes). Taxonomic identifications were made under compound or inverted microscopes and reference collections and/or photographs were maintained for each taxon for documentation and QA/QC purposes.

IV. Benthos

A. Fixed Location Sampling

Sixteen stations in the lower Chesapeake Bay were sampled quarterly (March, June, September, December) from March 1985 through December 1995 as part of the Benthic Biological Monitoring Program of the Chesapeake Bay Program. Beginning in 1996 sampling at the fixed stations occurred only in June and September and a stratified random sampling element was added to the program. Power and robustness analyses indicated that sampling during June and September would be sufficient for detecting long-term trends at the fixed locations while at the same time, allow funding resources to be reallocated to the probability-based random sampling regime (Alden et al., 1997). Stations were located within the mainstem of the bay and the major tributaries - the James, York and Rappahannock rivers (Figure 2-3). In the tributaries, stations were located within the tidal freshwater zone (TF5.5, TF4.2, TF3.3), turbidity maximum (transitional) zone (RET5.2, RET4.3, RET3.1), lower estuarine mesohaline muds (LE5.2, LE4.1, LE3.2) and lower estuarine polyhaline silty-sands (LE5.4, LE4.3). The tidal freshwater station within the York River

estuary was located in the Pamunkey River. In the Mainstem of the Bay three stations were located off the mouths of the major tributaries (CB8.1, CB6.4, CB6.1) and two stations in the deeper channels near the bay mouth (CB7.3E) and above the Rappahannock River near the Virginia-Maryland border (CB5.4).
In 1989, five additional stations were added to the program: two stations in the Southern Branch of the Elizabeth River (SBE2, SBE5) in regions exposed to contaminated sediments, a station in the transitional region of the James River (LE5.1), a station in the lower York River exposed to low dissolved oxygen events (LE4.3B), and a station in the lower Rappahannock River exposed to low dissolved oxygen events (LE3.4).

For the fixed point stations three replicate box core samples were collected for benthic community analysis. Each replicate had a surface area of 184 cm^2, a minimum depth of penetration to 25 cm within the sediment, was sieved on a 0.5 mm screen, relaxed in dilute isopropyl alcohol and preserved with a buffered formalin-rose bengal solution.

At each station on each collection date a 50g subsample of the surface sediment was taken for sediment analysis. Salinity and temperature were measured using a Beckman RS5-3 conductive salinometer and bottom dissolved oxygen was measured using a YSI Model 57 oxygen meter. For the original 16 stations see Dauer et al. (1992) for a summary of the pattern of bottom oxygen values, Dauer et al. (1993) for a summary of the distribution of contaminants in the sediments and Dauer (1993) for a summary of salinity, water depth, and sedimentary parameters.

B. Probability-based Sampling

In 1996 a probability-based sampling program was added to estimate the area of the Virginia Chesapeake Bay and its tributaries that met the Benthic Restoration Goals as indicated by the B-IBI (Ranasinghe et al., 1994; Weisberg et al., 1997; Alden et al., 2002). Four strata were defined and each stratum was sampled by 25 randomly allocated sites. The four strata were: 1) the James River; 2) the York River (including the Pamunkey and Mattaponi rivers); 3) the Rappahannock River; and 4) the Mainstem of the Chesapeake Bay. Each year a new set of 25 random sites was selected for each stratum.

Probability-based sampling within strata supplements data collected at fixed-point stations. Sampling design and methods for probability-based sampling are based upon those developed by EPA's Environmental Monitoring and Assessment Program (EMAP, Weisberg et al., 1993) and allow unbiased comparisons of conditions between strata (e.g., tributaries) of the Chesapeake Bay within the same collection year and within tributaries for between different years. The consistency of sampling design and methodologies for probability-based sampling between the Virginia and Maryland benthic monitoring programs allows bay-wide characterizations of the condition of the benthos for the Chesapeake Bay (Dauer 1999; Dauer and Rodi 1998a, 1998b, 1999, 2001, 2002).

Within each probability-based stratum, 25 random locations were sampled using a 0.04 m^2 Young grab. At each station one grab sample was taken for macrobenthic community analysis and a second grab sample for sediment particle size analysis and the determination of total volatile solids. All sampling processing for probability-based sampling stations were identical to those for the fixed stations. Physico-chemical measurements were also made at the random locations.

C. Laboratory Sample Processing

In the laboratory, each replicate was sorted and all the individuals identified to the lowest possible taxon and enumerated. Biomass was estimated for each taxon as ash-free dry weight (AFDW) by drying to constant weight at 60 ^{o}C and ashing at 550 ^{o}C for four hours. Biomass was expressed as the difference between the dry and ashed weight.

The sand fraction of each sediment sample was dry sieved and the silt-clay fraction was quantified by a pipette analysis using the techniques of Folk (1974). Total volatile solids for each sediment sample was determined as the AFDW weight of the sediment divided by the dry weight of the sediment, expressed as a percentage.

V. Statistical Analyses

In order to ensure that long-term trends in water quality and living resource data are correctly interpreted, a unified approach for conducting the statistical analyses and interpreting their results was developed. Statistical analytical procedures used in this study were based on guidelines developed by the CBP Monitoring Subcommittee's Tidal Monitoring and Assessment Workgroup.
For both status and trend analyses, the stations were grouped into segments based on the segmentation scheme developed by the Data Analysis Workgroup (Figure 2-2). Status and trend analyses were conducted for different seasonal time periods as defined for each monitoring component in Table 2-1.

A. Status Assessments

For the tidal water quality stations, relative status analyses were conducted using surface and bottom water quality measurements for six parameters: total nitrogen, dissolved inorganic nitrogen, total phosphorus, dissolved inorganic phosphorus, chlorophyll *a*, and total suspended solids. Status analyses were also performed on secchi depth and bottom dissolved oxygen. All analyses were conducted using water quality data collected from all of the Chesapeake Bay Mainstem and tributary collection stations from the January 1999 through December of 2001 except for bottom dissolved oxygen for which analyses were conducted using data collected only during the summer months of June through September.

The relative status of each station and segment was determined by comparison to a benchmark data set comprised of all data collected from 1985 to 1990 by both the Virginia and Maryland monitoring programs. Each station was rated as poor, fair, or good relative to the benchmark data. The ratings are obtained for data collected within each salinity zone with salinity zones being assigned using the Venice classification system (Symposium on the Classification of Brackish Waters, 1958). For each parameter in the benchmark data set, a transformation was chosen that yields a distribution that was symmetric and approximated by the logistic cumulative distribution function (CDF). In most cases, the logarithmic transformation was selected. A logistic CDF based on the mean and variance of each parameter of the benchmark data set was used to perform a probability integral transform on all data collected during the period of January, 1998 through December, 2001. This resulted in data in the interval (0,1) that follow a uniform distribution. The three year median of these transformed data was computed as an indicator of status for the period specified. The median of n observations taken from a uniform distribution follows a Beta distribution with parameters (m,m) where:

$$m = (n+1)/2$$

and n is the number of observations.

The transformed three year medians were compared to the Beta density distribution and status was determined by the placement of the transformed medians along the distribution. If the median was in the upper third of the distribution (where upper is chosen as the end of the distribution that is ecologically desirable) then the status rating is good, while a median in the middle third was rated fair, and a median in the lower third was rated poor. In most cases, serial dependence of the raw data resulted in greater than expected variance in the Beta density of the medians. To adjust for this, the variance of the Beta density was increased by a function of the ratio of among station variance to within station variance.

Because sampling regimes between monitoring programs varied with respect to the number of collection events within a given month and the number of replicate samples collected at each station varied, a uniform calculation protocol was adopted for use by both states to insure that the calculations were not inadvertently biased by these discrepancies. First, replicate values were combined by calculating a median for each station date and layer combination. Median values for each station month and year combination were calculated to combine separate cruises per month. Finally, station specific or segment specific median scores were calculated that were compared to the benchmark scale.

Status for phytoplankton, microzooplankton and mesozooplankton involved the calculation of relative status using the same technique as described for water quality relative status assessments.
For phytoplankton communities the following indicators were assessed: total phytoplankton community abundance, total phytoplankton community biomass, diatom abundance, dinoflagellate abundance, cyanobacteria abundance, picoplankton abundance, and primary productivity (carbon fixation). Benchmarks for picoplankton abundance were made using data collected only in Virginia since sampling protocols for the Maryland program did not include counts of epifluorescent picoplankton. Microzooplankton parameters assessed included total microzooplankton abundance, copepod nauplii abundance and rotifer abundance. Mesozooplankton parameters assessed included the Margalef diversity index, the Shannon-Weiner diversity index, and total mesozooplankton abundance. Note that the benchmarks for mesozooplankton data were made using data collected only in Virginia since the sampling protocols for the Maryland program does not include counts of epifluorescent picoplankton. A change in laboratory sample processing for the mesozooplankton

program occurred in 2000 and as a result only data collected through 1999 were used in both status and trend analyses for the mesozooplankton.

Status of benthic communities at each station was characterized using the three-year mean value (1999-2001) of the B-IBI (Weisberg et al., 1997). The B-IBI indicates whether the macrobenthic community meets the restoration goals developed for benthic habitats of the Chesapeake Bay. An index value that exceeds or equals 3.0 indicates that the macrobenthic community meets or exceeds the restoration goals developed for that habitat type while a value below 3.0 indicates that the macrobenthic community does not meet the restoration goals. Status of the benthic community was classified into four levels based on the B-IBI. Values less than or equal to 2 were classified as severely degraded, values from 2.0 to 2.6 were classified as degraded, values greater than 2.6 but less than 3.0 were classified as marginal, and values of 3.0 or more were classified as meeting goals.

Water quality data were assessed to determine if the SAV habitat requirements were met for the following parameters: light attenuation (KD), percentage of required light at the leaf surface (PLL) (0.5 and 1.0 m), total suspended solids, chlorophyll *a*, dissolved inorganic nitrogen, and dissolved inorganic phosphorus. Three year medians for the SAV growing season were compared to the SAV habitat requirement values (see Table 2-2) using a Mann-Whitney U-test. If the median values were significantly higher (lower for PLL) than the habitat requirement for that parameter then the parameter was considered to have failed to met the SAV habitat requirements and if the values were significantly lower (higher for PLL) than the habitat requirement then the parameter was to considered to have met the SAV habitat requirement. If there was no significant difference between the habitat requirements or there were insufficient data to conduct the analysis, the parameter was considered borderline.

B. Long-term Trend Analyses

1. Non-tidal water quality

Trend analyses were conducted on data collected at nine stations at and above the fall-line in the Virginia tributaries. Concentrations of water-quality constituents are often correlated with streamflow. Removal of natural flow variability allows examination of changes in water quality resulting from human activities. Flow-adjusted concentration trends were determined with a non-parametric Kendall-Theil analysis. The trend slope was the overall median of the pairwise slopes of residuals from a log-linear-regression model incorporating flow and season terms. For data sets with greater than five percent censored data, a range in slope and magnitude was defined by twice computing the median slope - first, with censored data equal to zero and second, with censored data equal to the maximum detection limit. For data sets with greater than twenty percent censored data, no results were reported. A p-value of 0.05 or less was considered significant for this analysis.

When considering the health of living resources, it is necessary to examine trends in concentrations that may be both flow- and human-induced. These concentrations were weighted, but not adjusted, for flow. The flow-weighting resulted in a more representative monthly concentration than the one point per month typical of many observed data sets. The volume of flow occurring between these infrequent sample dates is likely to have a pronounced effect on average concentrations in the tidal estuaries and other mixed receiving areas. Therefore trends in flow-weighted concentrations may correlate better with trends in estuarine concentrations. The linear trend in flow-weighted concentration was estimated by regressing flow-weighted concentrations with time. In most cases, the data was log-transformed in order to meet the assumptions of normality, constant variance, and linearity. A p-value of 0.01 or less was considered significant for this analysis.

2. Tidal water quality

The statistical tests used for the trend analyses were the Seasonal Kendall test for monotonic trends and the Van Belle and Hughes (Gilbert, 1987) tests for homogeneity of trends between stations, seasons, and station-season combinations. A p value of 0.05 was chosen as the statistical test criterion for all trend analyses. Recent studies on representative data sets from the Chesapeake Bay monitoring program have indicated that these tests are very powerful and robust, even when data violate most of the assumptions of parametric statistics (Alden et al., 1991; Alden et al., 1992b; Alden et al., 1994; Alden and Lane, 1996).

Trend analyses were conducted on the same suite of water quality parameters used for the status assessments and salinity and water temperature. Prior to the trend analyses, data were reduced to a single observation for each station month and layer combination by first calculating the median of all replicates for each layer by station and date and then calculating the median between all dates for a given station within each month. For all applicable water quality parameters, any values less then the highest detection limit were set to one half of the highest detection limit. For calculated parameters, each constituent parameter that was below the detection limit was set to one half of the detection limit and the parameter was then calculated.

Increasing trends in total nitrogen, dissolved inorganic nitrogen, total phosphorus, dissolved inorganic phosphorus, chlorophyll *a* and total suspended solids should indicate increased eutrophication and as a result positive slopes in these parameters indicate degrading conditions while negative slopes indicate improving water quality conditions. Increasing trends in secchi depth and bottom dissolved oxygen indicate increasing water clarity and reduced eutrophication, respectively and, as a result, indicate improving water quality conditions. Decreasing trends in these two parameters indicate degrading conditions.

3. Tidal water quality method corrections

In 1994, changes in analytical methods for estimating concentrations of total nitrogen, dissolved inorganic nitrogen, total phosphorus and dissolved inorganic phosphorus were implemented by the Department of Environmental Quality in order to improve the accuracy of concentration estimates. Procedural changes involved the implementation of automated sample processing on a Scalar auto-analyzer for nitrites (NO2F), nitrates-nitrites (NO23F), ammonia (NH4F) and orthophosphate (PO4F). In addition, particulate nitrogen(PN), total dissolved nitrogen (TDN), particulate phosphorus (PHOSP) and total dissolved phosphorus (TDP) were added to the suite of parameters measured via auto-analyzer while total Kjeldahl nitrogen (fixed and whole) and direct measurements of total phosphorus (TP) were discontinued. These changes resulted in step trends in the data for these parameters that must be accounted for prior to conducting trend analyses.

Data were corrected for method changes by conducting a multiple regression analysis on log transformed water quality data with the following terms: 1) a linear trend term (Time); 2) a non-linear trend term (Time^2); 3) a month term to control for the effect of seasonal cycles; 4) a station term to control for the effect of differences due to station location and; 5) a dummy variable term that accounts for the effect of any changes in methods (0=prior to method change, 1=after method change). Analyses were conducted by salinity regime. For parameter/salinity regime combinations with a significant method change effect (p. <0.05), coefficients for this model term were used as correction factors that were applied to the original data. The resulting "method corrected" data were analyzed for long-term trends using the seasonal Kendall trend test. A comparison was made between the method corrected trends and trends conducted on the original data to assess the effect of the method correction analysis on trend analysis results. For the Elizabeth River all segments except the Elizabeth River Mouth segment used the newer analytical methods from the inception of this program in 1989. Therefore, method corrections were only applied to the Elizabeth River Mouth segment.

4. Living resources

Trend analyses for phytoplankton communities were conducted on the following phytoplankton community indices: the phytoplankton IBI, total phytoplankton abundance (excluding picoplankton); total phytoplankton biomass (excluding picoplankton); the Margalef species diversity index, and C^{14} productivity. In addition, trend analyses were conducted on abundance and biomass values for the following taxonomic groups: diatoms; dinoflagellates; cyanobacteria; cryptomonads; chlorophytes; bloom producing species; and toxic bloom producing species.

The Margalef species diversity index was calculated as follows:

$$D = \frac{S - 1}{\log_2 N}$$

where S is the number of taxa in the sample and N is the number of individuals (Margalef, 1958).

Trend analyses were conducted by station using monthly medians of microzooplankton and mesozooplankton data collected from the beginning of the respective monitoring programs through December of 2001 and December of 1999 for microzooplankton and mesozooplankton, respectively.

Microzooplankton bioindicators used for the trend analyses included: total microzooplankton abundance; rotifer abundance; copepod nauplii abundance; oligotrich abundance; tintinnid abundance; sarcodinia abundance; and microzooplankton cladoceran abundance. Mesozooplankton bioindicators used for these analyses were: total mesozooplankton abundance (excluding copepod nauplii); holoplankton abundance; meroplankton abundance; indices of mesozooplankton community species diversity (including the total number of species collected, the Shannon-Weiner index, the Margalef diversity index, and Pielou's evenness); calanoid copepod abundance; cladoceran abundance; cyclopoid copepod abundance; *Acartia tonsa* abundance; *Bosmina longirostris* abundance; *Eurytemora spp.* abundance; and crab zoea abundance.

The Shannon Weiner diversity index (H') was calculated as follows:

$$H' = -\sum_{i=1}^{s} p_i \log_2 p_i$$

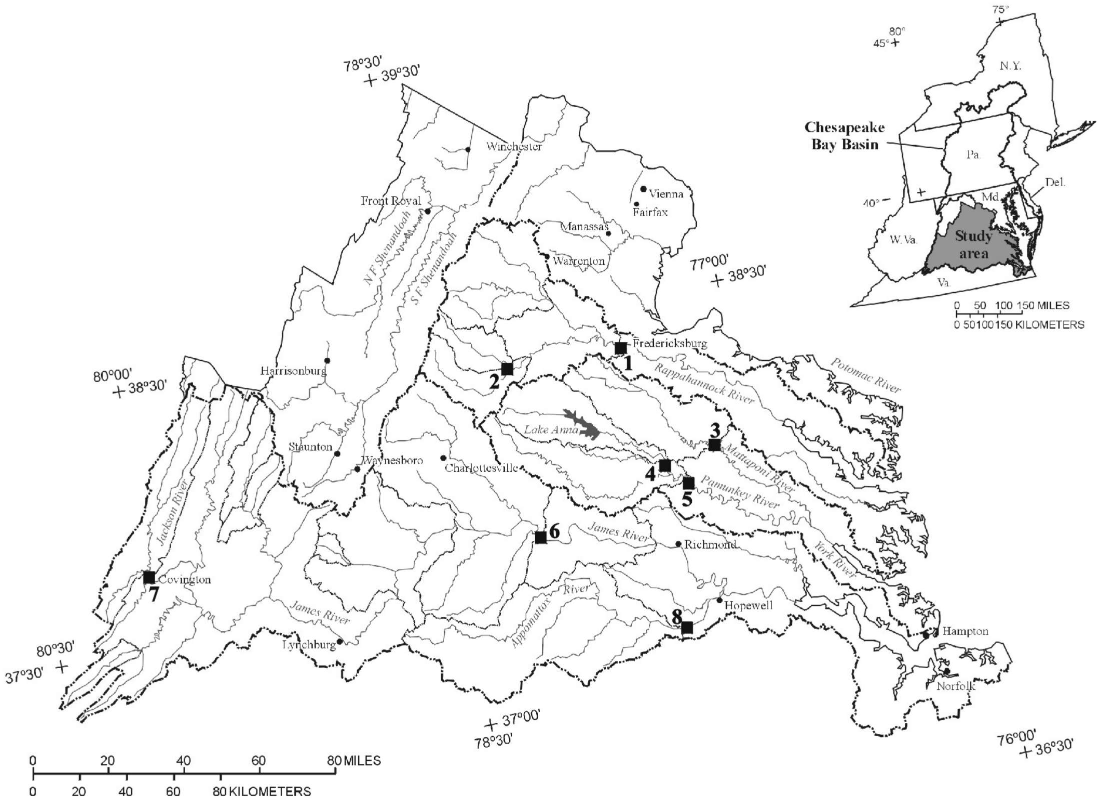
where p_i is the proportion of the ith species and S is the number of species.

Pielou's evenness index (J) was calculated using the equation:

$$J = \frac{H'}{\log_2 S}$$

where H' is the diversity index and S is the total number of species collected. Increasing trends in mesozooplankton abundance, holoplankton abundance, merozooplankton abundance and measures of species diversity indicate improving conditions while negative slopes indicate degrading conditions.

Trend analyses for benthic communities were conducted using the B-IBI (Ranasinghe et al., 1994; Weisberg et al., 1997) and on selected metrics of the B-IBI. Benthic restoration goals were developed for benthic habitats of the Chesapeake Bay based upon reference sites that were minimally impacted by low dissolved oxygen events and sediment contaminants. Goals were developed based upon data from an index period of July 15 through September 30. Therefore trends in the value of the B-IBI were based upon September cruise values for the 14 year period of 1985-1998. Selected benthic metrics were species diversity (H'), community abundance, community biomass, pollution-indicative species abundance, pollution-indicative species biomass, pollution-sensitive species abundance, and pollution-sensitive species biomass. See Weisberg et al. (1997) for a list of pollution-indicative and pollution-sensitive taxa.



1 Station 01668000 - Rappahannock River near Fredericksburg
2 Station 01666500 - Robinson River
3 Station 01674500 - Mattaponi River near Beulahville
4 Station 01671020 - North Anna River near Doswell
5 Station 01673000 - Pamunkey River near Hanover
6 Station 02035000 - James River at Cartersville
7 Station 02013100 - Jackson River at Covington
8 Station 02041650 - Appomattox River

Figure 2-1. Locations of the USGS sampling stations at and above the fall-line in each of the Virginia tributaries.

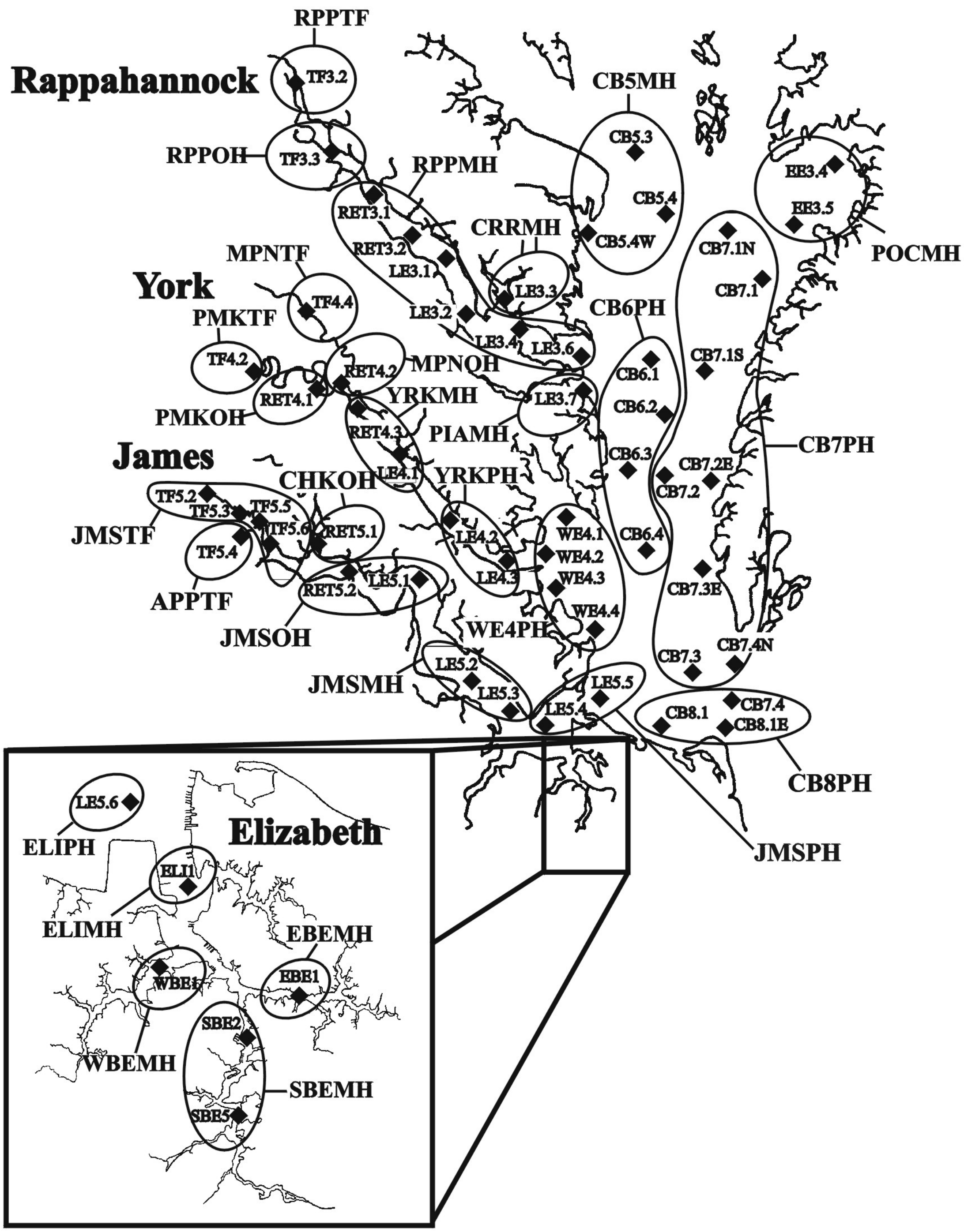


Figure 2-2. Map showing the locations of the water quality monitoring stations in the Virginia tributaries and the Lower Chesapeake Bay Mainstem used in the statistical analyses. Also shown are ellipses that delineate the Chesapeake Bay Program segmentation scheme.

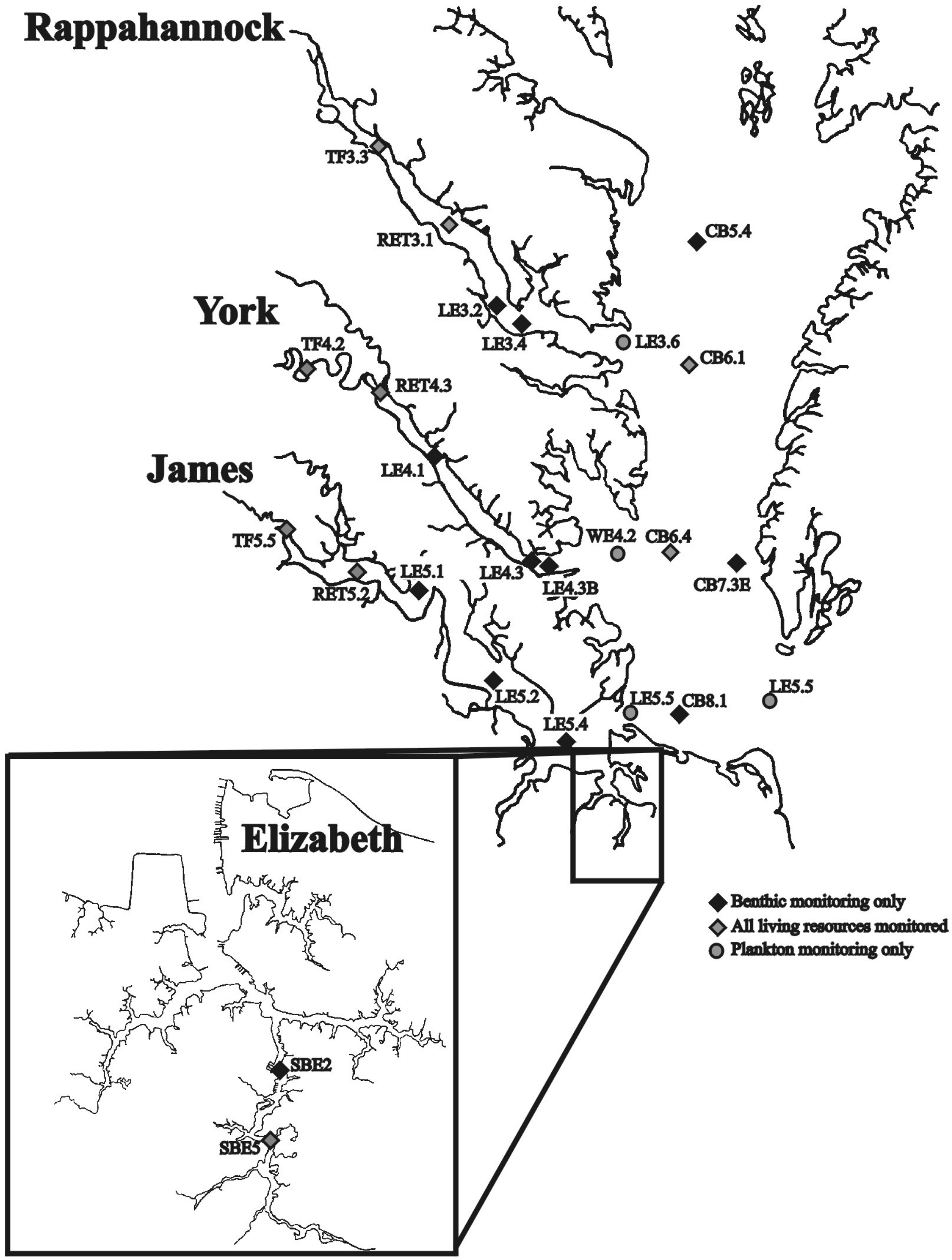


Figure 2-3. Location of living resource monitoring stations in the Virginia tributaries and the Lower Chesapeake Bay Mainstem.

Table 2-1. Definitions of seasonal time periods for status and trend analyses conducted for of the tidal monitoring programs. A "x" indicates the analysis was conducted for the season and parameter group combination while a "-" indicates that no analysis was conducted. *Note that benthic status and trend analyses were conducted on data collected from June 15 through September 30.

		Water Quality			Plankton		Benthos	
Season	**Definition**	**Status**	**Trend**	**SAV Goals**	**Status**	**Trend**	**Status**	**Trend**
Annual	Entire year	x	x	-	x	x	-	-
SAV1	March through May and September through November	x	x	x	x	x	-	-
SAV2	April through October	x	x	-	x	x	-	-
Summer1	June through September	x	x	-	x	x	x*	x*
Summer2	July through September	x	x	-	x	x	-	-
Spring1	March through May	x	x	-	x	x	-	-
Spring2	April through June	x	x	-	x	x	-	-
Fall	October through December	-	x	-	x	x	-	-
Winter	January and February	-	x	-	x	x	-	-

Table 2-2. Habitat requirements for growth and survival of SAV (from Batuik et al., 1992; 2000).

Salinity Regime	SAV Growth Season	Light Attenuation Coefficient (Kd)	Percent Light at Leaf	Total Suspended Solids (mg/l)	Chlorophyll *a* (µg/l)	Dissolved Inorganic Nitrogen (mg/l)	Dissolved Inorganic Phosphorus (mg/l)
Tidal Freshwater	Apr.-Oct.	<2	>9	<15	<15	none	<0.02
Oligohaline	Apr.- Oct.	<2	>9	<15	<15	none	<0.02
Mesohaline	Apr.-Oct.	<1.5	>15	<15	<15	<0.15	<0.01
Polyhaline	Mar.- May,	<1.5	>15	<15	<15	<0.15	<0.01

Chapter 3. Water Quality Method Correction Analyses

I. Method Change Effects

This chapter summarizes the effects of the changes in analytical methods for estimating concentrations of total nitrogen, dissolved inorganic nitrogen, total phosphorus and dissolved inorganic phosphorus implemented by the Department of Environmental Quality in 1994. Significant method effects were detected for both total nitrogen and total phosphorus in all salinity regimes. Correction factors for total nitrogen and total phosphorus indicate that the changes in analytical methods for these two parameters resulted in data that were lower in all salinity regimes after 1994. Significant method change effects were detected for dissolved inorganic nitrogen in the mesohaline (an increase in concentration after 1994) and the polyhaline (a decrease after 1994) salinity regimes. Significant method change effects were detected for dissolved inorganic phosphorus in all salinity regimes. Correction factors for this parameter indicate that the changes in analytical methods resulted in data that were lower in the tidal freshwater and oligohaline salinity regimes and higher in the mesohaline and polyhaline salinity regimes after 1994 (Table 3-1).

II. Trend Analysis Comparison

A. James River

Previous investigations using data collected through 2000 indicated widespread decreasing trends throughout the James River. However, addition of data collected in 2001 and application of method corrections for this parameter resulted in either the disappearance or reversal of the majority of these trends. The only improving trends which persisted in the corrected data set were detected in the Upper James River (JMSTF, surface and bottom) and the Chickahominy River (CHKOH, surface only) (Table 3-2).

In contrast to total nitrogen, trends in dissolved inorganic nitrogen for the "corrected" data were similar to those previously detected with the exception of the disappearance of two improving trends in the Lower James River (JMSMH) (Table 3-2).

Nearly all of the previously detected improving trends in total phosphorus disappeared or were reversed after application of the method corrections and addition of the data collected in 2001. In addition, degrading trends in "corrected" total phosphorus were detected in the Middle James River (JMSOH) and the Chickahominy River (CHKOH). The improving trends in both surface and bottom total phosphorus persisted in the Upper James River (JMSTF) despite the method correction and addition of the data collected in 2001 (Table 3-3).

The direction or absence of trends in dissolved inorganic phosphorus persisted within all tidal freshwater and oligohaline segments. However, in the Lower James River (JMSMH) and James River Mouth (JMSPH) previously detected improving trends reversed and disappeared, respectively, as a result of additional data from 2001 and application of the method corrections (Table 3-2).

B. Elizabeth River

For the majority of segments, no method corrections were applied and as a result few changes in pattern were observed. However, in the Elizabeth River Mouth previously detected improving trends reversed or disappeared (Table 3-3).

C. York River

As a result of the method corrections and addition of data collected in 2001, most of the previously detected improving trends in total nitrogen in the York River either reversed or disappeared. In addition, degrading trends in both surface and bottom total nitrogen appeared in the Lower Pamunkey River (segment PMKOH) and the Lower Mattaponi River (segment MPNOH) while degrading trends in bottom total nitrogen appeared in the Middle York River (segment YRKPH) and Lower York River (segment YRKPH) (Table 3-4).

Few trends in dissolved inorganic nitrogen were detected in the York River through 2000. This pattern persisted despite the addition of data for 2001 and the application of the method corrections. Two improving trends in dissolved inorganic nitrogen were previously detected but both disappeared in the method "corrected" data (Table 3-4).

As a result of the addition of data collected in 2001 and the application of the method corrections, degrading trends in total phosphorus appeared in nearly all segments of the York River and a previously detected improving trend in the Lower York River was reversed (Table 3-4).

In contrast, previously detected degrading trends in dissolved inorganic phosphorus in the Pamunkey and Mattaponi Rivers disappeared as a result of the addition of data collected in 2001 and the application of the method corrections. Two degrading trends in dissolved inorganic phosphorus appeared in the Middle York River (segment JMSOH) (Table 3-4).

D. Rappahannock River

As a result of the addition of the data collected in 2001 and the application of the method corrections, nearly all improving trends in total nitrogen in the Rappahannock River either disappeared or were reversed. In addition, two degrading trends in bottom total nitrogen appeared in the Middle Rappahannock River (segment RPPOH) and the Corrotoman River (CRRMH) (Table 3-5).

Previously detected improving trends in dissolved inorganic nitrogen in the Middle Rappahannock River (segment RPPOH) disappeared after addition of the data collected in 2001 and the application of the method corrections. A degrading trend in bottom dissolved inorganic nitrogen appeared in the Upper Rappahannock River (segment JMSTF) (Table 3-5).

Although few trends in total phosphorus were detected in the data collected through 2000, the addition of the data collected in 2001 and the application of the method corrections resulted in the appearance of widespread degrading trends in both surface and bottom total phosphorus (Table 3-5).

There were no changes in trend analysis results for dissolved inorganic phosphorus as a result of the addition of the data collected in 2001 and the application of the method corrections (Table 3-5).

Table 3-1. **Method change correction factors for each salinity regime. An "ns" indicates the method change effect was not significant (p>0.05). A "-" indicates that no method change analysis was performed for the parameter indicated. In the salinity regime column, an TF =Tidal freshwater, O =Oligohaline, M=Mesohaline, and P=Polyhaline.**

Salinity Zone	Total Nitrogen	Dissolved Inorganic Nitrogen	Dissolved Inorganic Phosphorus	Total Phosphorus
TF	0.8894	ns	1.3748	0.8000
O	0.7999	ns	1.0661	0.7821
M	0.8231	1.1003	0.8131	0.8424
P	0.7342	0.8209	0.6004	0.7115

Table 3-2. **Changes in the pattern of water quality trends between 2001 and 2000 analyses for the James River. Dark shading indicates a previously improving trend that changes to a degrading trend. Light shading indicates either (1) a previous improving trend that changes to no trend (Disappearance Improving), (2) or a previous no trend changing to a degrading trend (Appearance Degrading).**

	Appomattox	Upper James	Chickahominy	Middle James	Lower James	River Mouth
STN	Disappearance Improving	Same Improving	Same Improving	Disappearance Improving	Reversal Degrading	Reversal Degrading
BTN	Disappearance Improving	Same Improving	Disappearance Improving	Reversal Degrading	Reversal Degrading	Appearance Degrading
SDIN	Same NS	Same Improving	Same NS	Same Improving	Disappearance Improving	Same NS
BDIN	Same NS	Same Improving	Same NS	Same Improving	Disappearance Improving	Same NS
STP	Disappearance Improving	Same Improving	Appearance Degrading	Appearance Degrading	Reversal Degrading	Disappearance Improving
BTP	Reversal Degrading	Same Improving	Appearance Degrading	Appearance Degrading	Appearance Degrading	Disappearance Improving
SDIP	Same Improving	Same Improving	Same NS	Same NS	Reversal Degrading	Disappearance Improving
BDIP	Same Improving	Same Improving	Same NS	Same NS	Reversal Degrading	Disappearance Improving

Table 3-3. Changes in the pattern of water quality trends between 2001 and 2000 analyses for the Elizabeth River. See Table III-2 for shading explanation.

	Western Branch	Southern Branch	Eastern Branch	Elizabeth River Mainstem	Elizabeth River Mouth
STN	Same Improving	Same Improving	Same Improving	Appearance Improving	Reversal Degrading
BTN	Same Improving	Appearance Improving	Same Improving	Appearance Improving	Reversal Degrading
SDIN	Same Improving	Same Improving	Same Improving	Same Improving	Disappearance Improving
BDIN	Same Improving	Same Improving	Same Improving	Same Improving	Disappearance Improving
STP	Same Improving	Same Improving	Same Improving	Same Improving	Reversal Degrading
BTP	Same Improving	Same Improving	Same Improving	Same Improving	Reversal Degrading
SDIP	Same Improving	Same Improving	Same Improving	Same Improving	Disappearance Improving
BDIP	Same Improving	Same Improving	Same Improving	Same Improving	Disappearance Improving

Table 3-4. Changes in the pattern of water quality trends between 2001 and 2000 analyses for the York River. See Table III-2 for shading explanation.

	Upper Pamunkey	Lower Pamunkey	Upper Mattaponi	Lower Mattaponi	Middle York	Lower York	Mobjack Bay
STN	Disappearance Improving	Appearance Degrading	Disappearance Improving	Appearance Degrading	Reversal Degrading	Reversal Degrading	Disappearance Improving
BTN	Disappearance Improving	Appearance Degrading	Same Improving	Appearance Degrading	Appearance Degrading	Appearance Degrading	Reversal Degrading
SDIN	Same NS	Same NS	Same NS	Same NS	Disappearance Improving	Same NS	Same NS
BDIN	Same NS	Same NS	Same NS	Same NS	Same NS	Same NS	Disappearance Improving
STP	Appearance Degrading	Appearance Degrading	Appearance Degrading	Appearance Degrading	Appearance Degrading	Appearance Degrading	Appearance Degrading
BTP	Appearance Degrading	Appearance Degrading	Appearance Degrading	Appearance Degrading	Same Degrading	Reversal Degrading	Same NS
SDIP	Disappearance Degrading	Disappearance Degrading	Disappearance Degrading	Disappearance Degrading	Appearance Degrading	Same NS	Same NS
BDIP	Disappearance Degrading	Same NS	Disappearance Degrading	Disappearance Degrading	Appearance Degrading	Same NS	Same NS

Table 3-5. Changes in the pattern of water quality trends between 2001 and 2000 analyses for the Rappahannock River. See Table III-2 for shading explanation.

	Upper Rappahannock	Middle Rappahannock	Lower Rappahannock	Corrotoman
STN	Disappearance Improving	Disappearance Improving	Disappearance Improving	Reversal Degrading
BTN	Same Improving	Appearance Degrading	Disappearance Improving	Appearance Degrading
SDIN	Same NS	Disappearance Improving	Same NS	Same NS
BDIN	Appearance Degrading	Disappearance Improving	Same NS	Same NS
STP	Same NS	Appearance Degrading	Appearance Degrading	Appearance Degrading
BTP	Disappearance Improving	Appearance Degrading	Appearance Degrading	Same Degrading
SDIP	Same NS	Same NS	Same NS	Same NS
BDIP	Same NS	Same NS	Same NS	Same NS

Chapter 4. James River Basin

I. Executive Summary

A. Summary of Basin Characteristics

The James River basin is the largest river basin in Virginia covering 26,422 km^2 or nearly 25% of the Commonwealth's total area. The James River begins in the Allegheny Mountains where it is formed by the confluence of the Jackson and Cowpasture rivers. From its sources, the James River flows 547 km in a southeasterly direction to the fall-line near Richmond and for an additional 180 km to Hampton Roads where it enters Chesapeake Bay. Approximately 71% of the entire basin is forested and an additional 17% of the watershed is covered by agricultural land. All other land use types account for just over 12% of the basin. Approximately 16,600 km of the 44,290 km (38%) of streambanks and shoreline within the watershed have a 30 m minimum riparian forest buffer. The population in the James River basin for 2000 was 2,522,583 people with a population density of 93.4 individuals per km^2. Most of the basin's population is concentrated in approximately 5% of the watershed which consists of residential and industrial land found in the urban areas of Tidewater, Richmond, Petersburg, Lynchburg and Charlottesville.

Total point and non-point source loadings of nitrogen were estimated to be 16,132,907 kg/yr in 2000. Total point and non-point source loadings of phosphorus and sediments were approximately 2,587,742 kg/yr and 1,096,793 metric tons/yr, respectively in 2000. Point sources account for approximately 6,173,000 kg/yr of the total nitrogen loadings and 715,768 kg/yr of the total phosphorus loadings. Daily freshwater flow at the fall-line ranged from a minimum of 17.44 m^3/sec to a maximum of 5,635 m^3/sec for the period of January 1, 1985 through December 31, 2001. Grand mean flow at the fall-line was 201.89 m^3/sec. Figures 4-1 to 4-7 provide summary information of basin characteristics of the James River.

B. Summary of Status and Long Term Trends

Figures 4-8 to 4-13 provide summaries water quality status and trend analyses for the James and Elizabeth rivers. Status of nitrogen parameters was either good or fair in all segments of the James River. Relative status of total phosphorus and dissolved inorganic phosphorus was fair in the upper segments of the James River (JMSTF, APPTF, and CHKOH) and poor in the lower segments (JMSOH, JMSMH, JMSPH). Status of nutrients for most of the segments in the Elizabeth River was poor or fair except for the nitrogen parameters in the Western Branch (WBEMH) and the Elizabeth River Mainstem (ELIMH). Status of chlorophyll *a* was poor in all segments of the James River except for the Middle and Lower James River (JMSOH and JMSMH) were it was good. Status of total suspended solids was poor or fair in all segments in the James River and poor in most segments of the Elizabeth River. Status of water clarity was fair or poor in most segments of the James and poor in all segments of the Elizabeth River. Status of bottom dissolved oxygen was good throughout the James River and in most segments of the Elizabeth River. Most parameters either did not meet the SAV habitat requirements or were borderline within both the James and the Elizabeth rivers.

Degrading trends in method corrected total nitrogen were detected in the Middle James (JMSOH), the Lower James (JMSMH) and the James River Mouth (JMSPH). Degrading trends in method corrected total phosphorus were detected in total phosphorus were detected in the Middle and Lower James River (JMSOH and JMSMH) and the Appomattox River (APPTF), and the Chickahominy River. Degrading trends in total suspended solids were detected in all segments of the James River Basin except for the Middle James River (JMSOH) and the Appomattox River (APPTF). Improving trend in bottom dissolved oxygen were detected in half of the segments in the James River. Improving trends in all nutrients and bottom dissolved oxygen were detected in all segments of the Elizabeth River except for the Elizabeth River Mouth (ELIPH) where degrading trends in surface and bottom total nitrogen and total phosphorus and secchi depth were detected.

For data collected after the method correction (1995-2001), improving trends in total nitrogen were detected in the lower segments of the James River (JMSOH, JMSMH, JMSPH) while improving trends in dissolved inorganic nitrogen were detected in the Upper James River (JMSTF) and Middle James River (JMSOH). Improving trends in total phosphorus were detected in the Middle James (JMSOH) and the James River Mouth (JMSPH) while improving trends in dissolved inorganic phosphorus were detected in the Upper James River (JMSTF) and the Appomattox River (APPTF). Degrading trends in surface chlorophyll *a* were detected in the Upper James River (JMSTF) and the Appomattox River (APPTF). Degrading trends were detected in secchi depth in the Upper James River (JMSTF), Appomattox River and the Chickahominy River (CHKOH).

Figures 4-14 to 4-17 provide summaries of living resources status and trend analyses for the James River. Although, the phytoplankton composition in the James River is represented by favorable dominance and abundance levels of diatoms, chlorophytes, and cryptophytes, there are still signs for concern. For instance, the status of the cyanobacteria is poor throughout the tidal river stations, and they possess degrading trends in both increasing biomass and abundance. Similar unfavorable signs include the poor status of dinoflagellates at two of the three stations, and fair status at the other station. In addition, species diversity status is either poor or fair at these stations. Productivity rate status is poor at TF5.5, with mixed status downstream. Other indices and trends show mixed, or more favorable patterns, as with decreasing autotrophic picoplankton abundance and increasing biomass of diatoms. Should this trend reverse itself, and continued increases in the cyanobacteria and dinoflagellates continue, then there would be broad environmental impacts on trophic relationships in the river.

Degrading trends in both copepod nauplii and rotifer abundance were detected at station LE5.5 in the Polyhaline James River (JMSPH) and in rotifer abundance at station TF5.5 in the Tidal Freshwater James River (JMSTF). Status of copepod nauplii abundance was good at Tidal Freshwater James River (JMSTF), fair at station RET5.2 in the Oligohaline James River (JMSOH), and poor in the Polyhaline James River (JMSPH) and at SBE5 in the Southern Branch of the Elizabeth River (SBEMH). Status of rotifer abundance was poor in the Tidal Freshwater James River (JMSTF) and the Polyhaline James River (JMSPH) and good in the Oligohaline James River (JMSOH) and in the Southern Branch of the Elizabeth River (SBEMH).

Although changes in sample processing methods precluded performing status and trend analyses on mesozooplankton bioindicators, results of analyses conducted on data collected through 1999 indicate improving trends in meszooplankton species diversity in both the Tidal Freshwater James River (JMSTF) and the Oligohaline James River (JMSOH). Degrading trends in meszooplankton diversity indices were detected in the Polyhaline James River (JMSPH) and the Southern Branch of the Elizabeth River. Degrading trends were detected in nearly all mesozooplankton bioindicators in the Polyhaline James River (JMSPH).

Improving trends in the benthic IBI were detected in the Tidal Freshwater James River (JMSTF), the Oligohaline James River (JMSOH) and the Southern Branch of the Elizabeth River. The benthic IBI either met goals or was marginal within the main stem of the James River while status of the benthic IBI within the Elizabeth River was degraded.

C. Summary of Major Issues in the Basin

With respect to water quality, the primary concerns within the James River main stem are the fair to poor status of water clarity throughout the river and poor status in total phosphorus and dissolved inorganic phosphorus in the lower segments of the James. Nearly all segments in the James River basin had at least one parameter that did not meet the SAV habitat requirements. In addition, although many improving trends in water quality were detected in the Elizabeth River, the status of most parameters was poor. Although the problem with total phosphorus appears to be localized to the lower portions of the James River and the Elizabeth River, water clarity problems with the watershed are more widespread. Low freshwater flows in the James River during the last three years may have also have caused or exacerbated water quality problems in the James River. It is unclear whether the degrading trends in the method corrected data are the result of actual changes in water quality or artifacts of the method correction procedure. Trends detected in the data collected after the method change suggest that water quality conditions in the James River were improving rather than degrading. In addition, scatterplots of the method corrected data neither support nor discount the results of the trend analyses for most parameter/segment combinations.

With regard to algal levels, increasing cyanobacterial abundances throughout the river are of particular concern. Degrading trends in both microzooplankton and mesozooplankton bioindicators at the mouth of the river were associated with water clarity and salinity declines. Further consideration should be given to the ecological implications of these zooplankton trends specifically as it might affect stocks of planktivorous feeding fish. Although there was a significant improving trend in the B-IBI within the oligohaline James River at one station, the status of the B-IBI at both stations in this segment was marginal. Despite a significant improving trend in the B-IBI at one station, the status of the B-IBI within the Southern Branch of the Elizabeth River remains degraded.

II. Management Recommendations

Problems both with respect to water quality and living resources are still evident in the James River, despite improvements in point source nutrient loadings. Many of these problems appear to be localized primarily in the mesohaline and polyhaline segments of the James River and/or the Elizabeth River including: 1) fair and poor relative status of phosphorus in the lower segments of the James River; 2) fair and poor relative status of secchi depth and total suspended solids; 3) degrading trends in secchi depth and total suspended solids; 4) poor status and degrading trends in microzooplankton and mesozooplankton indicators and; 5) degraded benthic community status in the lower James River segments and Elizabeth River.

These segments are located in or near the largest concentration of urban land in the state of Virginia. This suggests that the environmental problems in these areas may be the result of their proximity to the point sources and urban non-point sources in this population center. Additional point source and non-point source controls will help alleviate these problems. If nutrient concentrations are not limiting in these areas, water clarity may be reduced by a high concentrations of total suspended solids and/or high phytoplankton concentrations caused by existing nutrient levels. Additional point and non-point nutrient controls could also ameliorate water clarity problems within these segments.

In contrast, problems with phytoplankton communities tended to be more widespread as exhibited by: 1) the occurrence of long-term degrading trends in cyanobacteria abundance and biomass; 2) the fair to poor status of dinoflagellates, and the poor status of cyanobacteria biomass ; 3) the poor status of the biomass to abundance ratio at all stations in this basin; and 4) the fair to poor status of phytoplankton species diversity. Problems with SAV habitat requirements also tended to be widespread. All segments except the polyhaline James River and the Western Branch of the Elizabeth River had at least one parameter which failed to meet the SAV Habitat Requirements. Within the lower portions of the James River and the segments located in the Elizabeth River, water quality problems are most likely caused by nutrient loadings from point source loadings and urban run-off.

The cause of water quality and living resource problems in the upper segments of the James River and the Appottomax and Chickahominy rivers is unclear. A more concerted effort should be placed on designing studies that can determine the cause of the water quality and living resource problems in these segments.

III. Overview of Monitoring Results

Status of surface and bottom total nitrogen and dissolved inorganic nitrogen was good in all segments of the James River except in the James River Mouth (JMSPH) were the status of surface and bottom total nitrogen and surface dissolved inorganic nitrogen was fair. Status of surface and bottom total phosphorus and dissolved inorganic phosphorus was fair in the upper segments of the James River (JMSTF, APPTF, and CHKOH) and poor in the lower segments (JMSOH, JMSMH, JMSPH) (Figure 4-8). Status of chlorophyll *a* was poor in all segments of the James River except for the Middle and Lower James River (JMSOH and JMSMH) were it was good. Status of water clarity was fair or poor in most segments of the James except for the Chickahominy River (CHKOH) and the Middle James River (JMSOH). Status of bottom dissolved oxygen was good throughout the James River (Figure 4-9)

Status of surface and bottom total nitrogen and dissolved inorganic phosphorus was poor in the Southern Branch of the Elizabeth River (SBEMH) and the Elizabeth River Mouth (ELIPH), fair in the Eastern Branch (EBEMH), and good in the Western Branch (WBEMH) and Elizabeth River Mainstem (ELIMH). Status of surface and bottom total phosphorus and dissolved inorganic phosphorus was poor or fair in all segments of the Elizabeth River (Figure 4-10). Status of surface chlorophyll *a* was good the Southern and Eastern Branch of the Elizabeth River (SBEMH and EBEMH), fair in the Elizabeth River Mainstem (ELIMH), and poor in the Western Branch and Elizabeth River Mouth (WBEMH and ELIPH). Status of surface and bottom total suspended solids was poor or fair in all segments in the James River and poor or fair in most segments of the Elizabeth River. Status of water clarity was poor in all segments of the Elizabeth River and in all segments of the Elizabeth River except for the Southern and Eastern branch (SBEMH and EBEMH) were it was fair (Figure 4-11).

Surface chlorophyll *a* met the SAV habitat requirements in the Middle James River (JMSOH), the Lower James River (JMSMH), and the James River Mouth (JMSPH). Surface dissolved inorganic phosphorus met the SAV habitat requirements in the Appomattox River (APPTF) and the Chickahominy River (CHKOH). SAV habitat requirements were met for all parameters at the James River Mouth except light attenuation and percent of light at the leaf surface at 1.0 meter. All other parameter/segment combinations either did not meet the SAV habitat requirements or were borderline.

Surface chlorophyll *a* met the SAV habitat requirement in all segments of the Elizabeth River except the Western Branch were it was borderline. Total suspended solids met the SAV requirements in the Southern Branch (SBEMH), the Eastern Branch (EBEMH) and the Elizabeth River Mouth (ELIPH). All remaining segment parameter combinations in the Elizabeth River either did not met the SAV habitat requirements or were borderline.

Improving trends in all method corrected nutrient parameters were detected in the Upper James River. Improving trends were detected in method corrected surface and bottom dissolved inorganic phosphorus in the Appomattox River (APPTF), surface and bottom total nitrogen in the Chickahominy River (CHKOH) and surface and bottom dissolved inorganic nitrogen in the Middle James River (JMSOH). Degrading trends in method corrected total nitrogen were detected in the Middle James (JMSOH), the Lower James (JMSMH) and the James River Mouth (JMSPH). Degrading trends in method corrected total phosphorus were detected in total phosphorus were detected in the Middle and Lower James River (JMSOH and JMSMH), the Appomattox River (APPTF), and the Chickahominy River (Figure 4-8). Degrading trends in total suspended solids were detected in all segments of the James River Basin except for the Middle James River (JMSOH) and the Appomattox River (APPTF). Improving trends in bottom dissolved oxygen were detected in half of the segments in the James River (Figure 4-9).

Improving trends in all nutrients were detected in all Elizabeth River segments except the Elizabeth River Mouth were degrading trends in surface and bottom total nitrogen and phosphorus. Improving trends in all nutrients and bottom dissolved oxygen were detected in all segments of the Elizabeth River except for the Elizabeth River Mouth (ELIPH) where degrading trends in surface and bottom total nitrogen and total phosphorus and secchi depth were detected (Figures 4-10 and 4-11).

For data collected after the method correction (1995-2001), improving trends in total nitrogen were detected in the lower segments of the James River (JMSOH, JMSMH, JMSPH) while improving trends in dissolved inorganic nitrogen were detected in the Upper James River (JMSTF) and Middle James River (JMSMH). Improving trends in total phosphorus were detected in the Middle James (JMSOH) and the James River Mouth (JMSPH) while improving trends in dissolved inorganic phosphorus were detected in the Upper James River (JMSTF) and the Appomattox River (APPTF). Degrading trends in surface chlorophyll *a* were detected in the Upper James River (JMSTF) and the Appomattox River (APPTF). Degrading trends were detected in secchi depth in the Upper James River (JMSTF), Appomattox River and the Chickahominy River (CHKOH) (Figure 4-12 and 4-13).

Long term trend and status analysis results for living resources are summarized for all stations in James River in Figures 4-14 to 4-17. Long term trends indicate a general pattern of increased phytoplankton abundance in the upper and middle stations, and no significant change at the river mouth. Phytoplankton biomass also had increasing trends at each station, with the biomass status degrading from good to poor downstream. Contributing to these increases are a combination of favorable and unfavorable categories of algae. In general diatoms, chlorophytes, and cryptophytes represent the more favorable components that show increased trends in biomass and favorable status, but these are accompanied by the less favorable increase of cyanobacteria abundance and biomass. Also, less favorable is the poor status associated with the dinoflagellates and cyanobacteria. However, the procaryote to eukaryote ratio shows no significant change, with improvement indicated in the biomass to abundance ratio, while still retaining poor status. Within the river species diversity status was fair to poor, with a general pattern of a decreasing trend in productivity, possibly associated with levels of suspended solids in the system. Of note, are the favorable trends at all the tidal stations of decreasing autotrophic picoplankton abundance, plus its favorable status at these stations. The floral composition within this river goes through a transition from predominantly fresh water species to estuarine flora downstream. Upstream the composition is dominated by diatoms, with chlorophytes and cyanobacteria background species, and dinoflagellates less common. Moving downstream, estuarine diatoms (a different composition), dinoflagellates, chlorophytes, and cyanobacteria replace the fresh water forms. The Elizabeth River flora is most similar to that of the lower Chesapeake Bay. Becoming more abundant in the lower reaches of the James River and various inlets are frequent dinoflagellate blooms.

Microzooplankton trends were unchanged from last year with degrading trends in both copepod nauplii abundance and rotifer abundance at the mouth of the James with a degrading trend in rotifer abundance in the tidal fresh segment. The degrading trends in the lower part of the basin were most probably related to the water quality trends evident in the mainstem, such as degrading secchi depth, total suspended solids, and decreased salinity. Microzooplankton status was poor for rotifer abundance and good for copepod nauplii abundance throughout the James River basin. A change in methodology prevents a critical review of the status and trends in the mesozooplankton monitoring results. However, plots of raw data indicate that relative abundances and numbers of species of mesozooplankton were mostly unchanged from last year. The related water quality trends (mostly secchi depth and salinity) have not changed much from last year and therefore it is likely that the general mesozooplankton status and trends did not change much from last year. Therefore, it is likely that mesozooplankton diversity continued to decline in the lower part of the basin while the upper part of the basin should have continued to improve.

Microzooplankton trends for the Elizabeth River were degrading for copepod nauplii and decreasing for most other parameters: total abundance, oligotrich abundance, tintinnid abundance, and polychaeta larvae abundance. Although rotifer abundance status was good, the poor copepod nauplii status and decreasing trends in most microzooplankton parameters reflected the generally poor status of most water quality parameters.

Benthic community status in all segments of the James River was good except for stations RET5.2 in the Middle James River (JMSOH) and LE5.2 in the Lower James River (JMSMH) where the status was marginal. Improving trends in the B-IBI were detected at station TF5.5 in the Upper James River (JMSTF) and station RET5.2 in the Middle James River (JMSOH). Benthic community status in the Southern Branch (SBEMH) was poor at both station SBE5 and station SBE2. An improving trend in the B-IBI was detected at station SBE5 and was related to improving trends in several metrics measuring community composition including pollution indicative and pollution sensitive species biomass and abundance.

IV. Overview of Basin Characteristics

The James River basin is the largest river basin in Virginia covering 26,422 km^2 or nearly 25% of the Commonwealth's total area. The James River begins in the Allegheny Mountains where it is formed by the confluence of the Jackson and Cowpasture rivers. From its sources, the James River flows 547 km in a southeasterly direction to the fall-line near Richmond and for an additional 180 km to Hampton Roads where it enters Chesapeake Bay.

The population in the James River basin grew from 2,288,366 individuals in 1990 to 2,522,583 individuals in 2000 (Figure 4-1a) with a basin-wide population density of 93.4 individuals per km^2. Most of the basin's population is concentrated in approximately 5% of the watershed which consists of residential and industrial land found in the urban areas of Tidewater, Richmond, Petersburg, Lynchburg and Charlottesville. Population density in the James River Basin ranges from 108.45 individuals per km^2 in the Middle James River (JMSOH) to 894.53 individuals per km^2 in at the James River Mouth in the vicinity of Hampton Roads (Figure 4-1b).

Approximately 71% of the entire basin is forested and an additional 17% of the watershed is covered by agricultural land. All other land use types account for just over 12% of the basin. Approximately 16,600 km of the 44,290 km (38%) of streambanks and shoreline within the watershed has a 30 m minimum riparian forest buffer. In terms of total area, both forested and agricultural land use types were highest in the region around the Upper James River segment (Figure 4-2a), and accounted for 723.5 km^2 and 262.34 km^2 of land, respectively. The percentage of forested land within sub-watersheds of the James River remained relatively stable at 45% or more of the total sub-watershed from the Middle James River to the Appomattox River. However the percentage of forested land decreased to just under 35% in the Lower James River and to less than 10% at the James River Mouth (Figure 4-2b).

Total point and non-point source loadings of nitrogen were estimated to be 16,132,907 kg/yr in 2000. Total point and non-point source loadings of phosphorus and sediments were approximately 2,587,742 kg/yr and 1,096,793 metric tons/yr, respectively in 2000. Point sources account for approximately 6,173,000 kg/yr (38%) of the total nitrogen loadings and 715,768 kg/yr (nearly 28%) of the total phosphorus loadings (Figure 4-3a-b). Agricultural and forested land accounted for 494,418,550 kg/yr (45%) and 390,099,890 (36%) of the total suspended sediment loadings (Figure 4-3c).

Point source loadings of total nitrogen decreased from 11,174,755 kg/yr in 1985 to 6,672,152 kg/yr in 1999 (Figure 4-4a). Point source phosphorus showed a similar improving trend, decreasing from 1,766,105 kg/yr in 1985 to 649,550 kg/yr in 1999 (Figure 4-4b). Point source discharges for both total nitrogen and total phosphorus appear to be concentrated within the Upper James River (JMSTF) and the James River Mouth (JMSPH) (Figure 4-5a-b).

The ratio of impacted (agricultural and urban) to forested land use peaks in the region around the James River Mouth (Figure 4-6). This suggests that the area around this segment would be more likely than other regions in the basin to experience high non-point source loadings of both nutrients and sediments from agricultural and urban land.

Daily freshwater flow at the fall-line ranged from a minimum of 17.44 m^3/sec to a maximum of 5635 m^3/sec for the period of January 1, 1985 through December 31, 2001. Grand mean flow at the fall-line was 201.89 m^3/sec. Although there was no significant trend in freshwater flow at the James River fall-line, the annual peaks in monthly mean flow during the last three years appear to be much lower than during previous years (Figure 4-7a) and annual mean flow ranged from approximately 40% to 50% lower than the grand mean flow during the last three years (Figure 4-7b).

V. Detailed Overview of Status and Trends

A. Fall Line

In the James River at Cartersville, improving trends in flow adjusted concentrations, flow weighted concentrations, and loadings of total nitrogen were detected at the fall-line at Cartersville.

Improvements in total nitrogen at this station may have been related to improving trends in flow-adjusted concentrations, flow weighted concentrations, and loadings of nitrate-nitrites (fixed). Improving trends in total phosphorus and dissolved inorganic phosphorus flow adjusted concentrations, flow weighted concentrations, and loadings were detected at Cartersville. Improving trends in flow weighted concentrations and loadings of total suspended solids were detected at this station (Table 4-1). A decreasing trend in flow at the fall-line was also detected (Table 4-1).

In the James River at Bent Creek, improving trends in flow adjusted concentrations, flow weighted concentrations and loadings of total nitrogen were detected (Table 4-1). The trends in total nitrogen were related to reductions in the dissolved inorganic nitrogen species and not organic nitrogen compounds as is indicated by the improving trends in flow adjusted concentrations, flow weighted concentrations and loadings of ammonia, nitrate-nitrites (whole) and nitrates (whole) and by the degrading trends in flow adjusted and flow weighted concentrations of total Kjeldahl nitrogen detected at this station. Improving trends in flow adjusted concentrations, flow weighted concentrations and loadings of total phosphorus were also detected (Table 4-1).

In the James River at Scottsville, improving trends in flow adjusted concentrations, flow weighted concentrations and loadings of total nitrogen were detected. The trends in total nitrogen were related to reductions in the dissolved inorganic nitrogen species and not organic nitrogen compounds as is indicated by the improving trends in flow adjusted concentrations, flow weighted concentrations and loadings of ammonia, nitrate-nitrites (whole) and nitrates (whole) and by the degrading trend in flow weighted concentration of total Kjeldahl nitrogen detected at this station (Table 4-1). Improving trends in flow adjusted concentrations, flow weighted concentrations and loadings of total phosphorus were also detected (Table 4-1).

In the Appomattox River at Matoaca, improving trends were detected in loadings of total nitrogen and flow adjusted concentrations and loadings of nitrates-nitrites (fixed) (Table 4-1). Improving trends in loadings of total phosphorus and flow adjusted concentrations, flow weighted concentrations and loadings of dissolved inorganic phosphorus were also detected at this station. A degrading trend in flow-adjusted concentrations of total suspended solids was detected at this station (Table 4-1). A decreasing trend in flow was also detected at this station (Table 4-1).

B. Polyhaline James River (JMSPH - River Mouth)

1. Water quality for living resources

Status was fair or poor in the Polyhaline James River Mouth segment for all water quality parameters except for bottom dissolved inorganic nitrogen and dissolved oxygen which was good (Table 4-3). An improving trend was detected for bottom dissolved oxygen, while degrading trends were observed for total nitrogen (both surface and bottom) and for surface total suspended solids and secchi depth (Table 4-2). An increasing trend for bottom water temperature and a decreasing trend for bottom water salinity were also detected. Trends for all other parameters were not significant.

2. Water quality for SAV

Degrading trends in surface total nitrogen, total suspended solids, and secchi depth were detected in this segment (Table 4-4). Although relative status for total nitrogen during the SAV growing season was good, relative status for the remaining parameters was either fair or poor. Although SAV habitat requirements were met for surface dissolved inorganic nitrogen, surface dissolved inorganic phosphorus, and surface chlorophyll *a*, surface total suspended solids and percentage of light at the leaf surface at 0.5 meters, percentage of light at the leaf surface for 1.0 meter failed to meet the SAV habitat requirement and light attenuation (KD) was borderline (Table 4-5).

3. Water quality trends for 1995-2001

Status was fair or poor in the Polyhaline James River Mouth segment for all water quality parameters except for bottom dissolved inorganic nitrogen and dissolved oxygen which was good. Improving trends in surface total nitrogen, surface and bottom total phosphorus and bottom dissolved oxygen were detected in this segment. Increasing trends in bottom water temperature and surface salinity were also detected (Figures 4-12 and 4-13).

4. Living resources

This region contained a mixed representation of the phytoplankton in the various status categories. Poor status was identified for cyanobacteria biomass, accompanied by a degrading trend of increased cyanobacteria abundance. Poor status was also associated with total phytoplankton biomass, biomass to cell abundance ratio, and species diversity. Productivity status was fair. The diatom status was fair but also contained a favorable trend for increased biomass, whereas the dinoflagellate status was fair. In contrast, the chlorophyte and autotrophic picoplankton biomass status were both good, with positive trends (Figure 4-14). There were no significant trends associated with the cryptophytes or dinoflagellates. However, this region is prone to repeated dinoflagellates blooms from spring through early fall. These blooms are generally of short duration, with restricted areal coverage.

Uniform degrading trends continued for this segment for the two major microzooplankton parameters with decreasing copepod nauplii abundance and increasing rotifer abundance (Figure 4-15). This was probably reflective of degrading trends in water quality parameters.

Benthic community status was good with no trend in the B-IBI at station LE5.4 (Figure 4-17).

C. Mesohaline James River (JMSMH - Lower James)

1. Water quality for living resources

Status was good in the Lower James segment for surface and bottom total nitrogen, surface and bottom dissolved inorganic nitrogen, surface chlorophyll *a* , and bottom dissolved oxygen, but status was poor for surface and bottom total phosphorus, surface and bottom dissolved inorganic phosphorus, surface and bottom total suspended solids and secchi depth (Table 4-7). No improving trends were detected for any parameter, and degrading trends were observed for total nitrogen (both surface and bottom), total phosphorus (both surface and bottom), dissolved inorganic phosphorus (both surface and bottom), and for bottom total suspended solids (Table 4-6). Trends for all other parameters were not significant.

2. Water quality for SAV

Degrading trends in surface total nitrogen, total phosphorus, and dissolved inorganic phosphorus were detected in this segment (Table 4-8). Relative status was good for surface total nitrogen and chlorophyll *a*, fair for surface dissolved inorganic nitrogen and poor for the remaining parameters. SAV habitat requirements were met for only chlorophyll *a* while the remainder of parameters either failed to meet requirements or were borderline (Table 4-9).

3. Water quality trends for 1995-2001

An improving trend in surface total nitrogen was detected in this segment along with an increasing trend in surface salinity (Figure 4-12 and 4-13).

4. Living resources

Phytoplankton and zooplankton monitoring is not conducted within this segment.

Benthic community status at station LE5.2 was marginal with no trend in the B-IBI (Figure 4-17).

D. Oligohaline James River (JMSOH - Middle James)

1. Water quality for living resources

Status was good in the Middle James segment for surface and bottom total nitrogen, surface and bottom dissolved inorganic nitrogen, surface total phosphorus, surface chlorophyll *a*, secchi depth, and bottom dissolved oxygen, but status was poor for surface and bottom dissolved inorganic phosphorus, and bottom total suspended solids; status was fair for bottom total phosphorus and surface total suspended solids (Table 4-11). Improving trends were detected for surface and bottom dissolved inorganic nitrogen, and for surface total suspended solids (Table 4-10). Degrading trends were observed for bottom total nitrogen and for total phosphorus (both surface and bottom) (Table 4-10). Surface and bottom salinities showed an increasing trend. Trends for all other parameters were not significant.

2. Water quality for SAV

Improving trends in surface dissolved inorganic nitrogen and the percentage of light at the leaf surface at 0.5 meters were detected in this segment while degrading trends in surface total phosphorus, and dissolved inorganic phosphorus were detected (Table 4-12). Relative status was good for surface total nitrogen and chlorophyll *a*, fair for surface dissolved inorganic nitrogen and poor for the remaining parameters. SAV habitat requirements were met for only chlorophyll *a* while the remainder of parameters either failed to meet requirements or were borderline (Table 4-13).

3. Water quality trends for 1995-2001

Improving trends in surface and bottom total nitrogen, bottom dissolved inorganic nitrogen and bottom total phosphorus were detected in this segment. Increasing trends in surface and bottom salinity were also detected (Figure 4-12 and 4-13).

4. Living resources

There were mixed patterns status and trends among the phytoplankton components. This region was dominated by favorable status and trends for the diatoms, chlorophytes, and autotrophic picoplankton, with the cryptophytes also possessing a favorable trend. In general, there was an increasing trend in phytoplankton abundance and biomass, the biomass to cell abundance ratio. However, the status was poor for the biomass to cell abundance ratio, with species diversity status fair. The degrading status was also associated with the dinoflagellate biomass, and cyanobacteria biomass. There were degrading trends in cyanobacteria biomass and abundance. The significance of these trends will depend upon their duration and their subsequent influence on the trophic relationships in this region of the river (Figure 4-14).

There were no significant microzooplankton trends for this part of the basin. The status of the major indicators was mixed with poor rotifer abundance and good copepod nauplii abundance. This may reflect the generally poor to fair suspended solid status but good to fair nutrient status of this segment (Figure 4-15).

Benthic community status was marginal with an improving trend B-IBI at station RET5.2 and good at station LE5.1 with no trend (Figure 4-17) .

E. Tidal Fresh James River (JMSTF - Upper James)

1. Water quality for living resources

Status was good in the Tidal Fresh James segment for surface and bottom total nitrogen, surface and bottom dissolved inorganic nitrogen, and bottom dissolved oxygen, and status was fair for surface and bottom total phosphorus, surface and bottom dissolved inorganic phosphorus, surface and bottom total suspended solids, and secchi depth; however, status was poor for surface chlorophyll *a* (Table 4-15). Improving trends were detected for all water quality parameters in this segment except for the degrading trends observed for surface chlorophyll *a* and bottom total suspended solids (Table 4-14). Trends for the remaining parameters were not significant.

2. Water quality for SAV

Improving trends in surface total nitrogen, dissolved inorganic nitrogen, total phosphorus and dissolved inorganic phosphorus were detected in this segment (Table 4-16). Relative status was good or fair for all parameters except chlorophyll *a.* SAV habitat requirements were not met for any parameters in this segment (Table 4-17).

3. Water quality trends for 1995-2001

Improving trends were detected in surface and bottom dissolved inorganic nitrogen and phosphorus; however, degrading trends in surface chlorophyll *a* and secchi depth were also detected in this segment (Figure 4-12 and 4-13).

4. Living resources

There were numerous signs of poor status among the phytoplankton indicators, although there also existed signs of improving trends in several of these areas. For instance, the biomass to cell concentration ratio and species diversity status was poor, but their trends were positive. In contrast, the status of productivity and dinoflagellate biomass were both poor, with no significant trends. Favorable status was associated with diatom, chlorophyte, and autotrophic picoplankton biomass, and with each showing favorable trends. In general, total phytoplankton abundance and biomass were increasing. Of concern is that the cyanobacteria biomass status is poor, with degrading trends for both cyanobacteria biomass and abundance (Figure 4-14).

Microzooplankton indicated a degrading trend and poor status in rotifer abundance. This may relate to the generally fair to poor status of chlorophyl a, suspended solids, and secchi depth for this segment. However, the good status of copepod nauplii abundance may have reflected the generally good to fair status of the major nutrients (Figure 4-15).

Benthic community status was good with a strongly improving trend in the B-IBI and most of the benthic metrics of the B-IBI (Figure 4-17).

F. Tidal Fresh Appomattox (APPTF - Appomattox)

1. Water quality for living resources

Status was good in the Tidal Fresh Appomattox segment for surface and bottom total nitrogen, surface and bottom dissolved inorganic nitrogen, surface and bottom dissolved inorganic phosphorus, and bottom dissolved oxygen. Status was fair for surface and bottom total phosphorus, bottom total suspended solids, and secchi depth; however, status was poor for surface chlorophyll *a* and surface total suspended solids (Table 4-19). Improving trends were detected in the Tidal Fresh Appomattox segment for surface and bottom dissolved inorganic phosphorus and bottom dissolved oxygen (Table 4-18). A degrading trend was observed for bottom total phosphorus. Surface and bottom water temperatures showed an increasing trend. Trends for the remaining parameters were not significant.

2. Water quality for SAV

Improving trends in surface total nitrogen and dissolved inorganic phosphorus were detected in this segment (Table 4-20). Relative status was good for surface total nitrogen, dissolved inorganic nitrogen and dissolved inorganic phosphorus, fair for total phosphorus and secchi depth, and poor for chlorophyll *a* and total suspended solids. Although SAV habitat requirements were met for chlorophyll *a*, all other parameters failed to meet their appropriate criteria (Table 4-21).

3. Water quality trends for 1995-2001

Improving trends were detected in surface and bottom dissolved inorganic phosphorus ; however, degrading trends in surface chlorophyll *a* and secchi depth were also detected in this segment (Figure 4-12 and 4-13).

4. Living resources

Living resource monitoring is not conducted within this segment.

G. Oligohaline Chickahominy River (CHKOH - Chickahominy)

1. Water quality for living resources

Status was good in the Oligohaline Chickahominy segment for surface and bottom total nitrogen, surface and bottom dissolved inorganic nitrogen, bottom total phosphorus, secchi depth and bottom dissolved oxygen (Table 4-23). Status was fair for surface total phosphorus, surface and bottom dissolved inorganic phosphorus, and for surface and bottom total suspended solids. Status was poor for surface chlorophyll *a*. The only improving trend detected in the Tidal Fresh Appomattox segment was for surface total nitrogen (Table 4-22). Degrading trends were observed for surface and bottom total phosphorus, and surface and bottom total suspended solids. Trends for the remaining parameters were not significant.

2. Water quality for SAV

Degrading trends were detected in surface total suspended solids, secchi depth, and the percentage of light at the leaf surface at both 0.5 and 1.0 meters (Table 24). Relative status of surface total nitrogen, dissolved inorganic nitrogen, total phosphorus, and secchi depth was good. Relative status was fair for surface dissolved inorganic phosphorus and total suspended solids and poor for chlorophyll *a*. The majority of parameters either failed to meet the SAV habitat requirements or were borderline with the exception of dissolved inorganic phosphorus.

3. Water quality trends for 1995-2001

A degrading trend in secchi depth was detected in this segment along with increasing trends in surface and bottom salinity. No improving trends were detected in this segment (Figure 4-12 and Figure 4-13).

4. Living resources

Living resource monitoring is not conducted within this segment.

H. Polyhaline Elizabeth River (ELIPH - River Mouth)

1. Water quality for living resources

Status was poor in the Polyhaline Elizabeth River Mouth segment for all water quality parameters except for surface total suspended solids whose status was fair (Table 4-27). The only improving trend detected was for surface total suspended solids (Table 4-26). Degrading trends were observed for surface and bottom total nitrogen, surface and bottom total phosphorus, and secchi depth. Trends for the remaining parameters were not significant.

2. Water quality for SAV

Improving trends in surface total suspended solids and the percentage of light at the leaf surface at 0.5 meters in this segment while degrading trends in surface total nitrogen and secchi depth were also detected (Table 4-28). The relative status of all parameters was poor except for surface total suspended solids for which relative status was fair. Only two parameters, surface chlorophyll *a* and total suspended solids met the SAV habitat requirements (Table 4-29).

3. Living resources

Living resource monitoring is not conducted within this segment.

I. Mesohaline Elizabeth River (ELIMH - River Mainstem)

1. Water quality for living resources

Status was good in the Mesohaline Elizabeth River segment for surface and bottom total nitrogen, bottom dissolved inorganic nitrogen, and bottom dissolved oxygen (Table 4-31). Status was fair for surface dissolved inorganic nitrogen, and surface chlorophyll *a*. Status was poor for surface and bottom total phosphorus, surface and bottom dissolved inorganic phosphorus, surface and bottom total suspended solids, and secchi depth. Improving trends were detected in the Mesohaline Elizabeth River segment for surface and bottom total nitrogen and total phosphorus, surface and bottom dissolved inorganic nitrogen and dissolved inorganic phosphorus, and bottom dissolved oxygen (Table 4-30). No degrading trends were observed. Bottom water temperature and surface water salinity showed increasing trends. Trends for the remaining parameters were not significant.

2. Water quality for SAV

Improving trends were detected in surface dissolved inorganic nitrogen, total phosphorus, and dissolved inorganic phosphorus were detected in this segment (Table 4-32). Relative status of all parameters was poor except for surface total nitrogen and chlorophyll *a* for which the relative status was good. Chlorophyll *a* was the only parameter that met the SAV habitat requirements for this segment (Table 4-33).

3. Living resources

Phytoplankton and zooplankton monitoring is not conducted within this segment.

J. Western Branch of the Elizabeth River (WBEMH - Western Branch)

1. Water quality for living resources

Status was good in the Elizabeth River Western Branch segment only for surface and bottom total nitrogen, surface and bottom dissolved inorganic nitrogen, and bottom dissolved oxygen (Table 4-35). Status was poor for all other parameters. Improving trends were detected in the Elizabeth River Western Branch segment for surface and bottom total nitrogen and total phosphorus, surface and bottom dissolved inorganic nitrogen and dissolved inorganic phosphorus, surface chlorophyll *a*, and bottom dissolved oxygen (Table 4-34). No degrading trends were observed. Surface and bottom water salinity showed increasing trends. Trends for the remaining parameters were not significant.

2. Water quality for SAV

Improving trends were detected in surface total nitrogen, dissolved inorganic nitrogen, total phosphorus, dissolved inorganic phosphorus and chlorophyll *a* (Table 4-36). Relative status of all parameters was poor except for surface total nitrogen and dissolved inorganic nitrogen for which the relative status was fair. All parameters either failed to meet the SAV habitat requirements or were borderline (Table 4-37).

3. Living resources

Phytoplankton and zooplankton monitoring is not conducted within this segment.

K. Southern Branch of the Elizabeth River (SBEMH - Southern Branch)

1. Water quality for living resources

Status was poor in the Elizabeth River Southern Branch segment for all water quality parameters except status was good for surface chlorophyll *a* and bottom total suspended solids, and status was fair for surface total suspended solids and bottom dissolved oxygen (Table 4-39). Improving trends were detected in the Elizabeth River Southern Branch segment for surface and bottom total nitrogen and total phosphorus, surface and bottom dissolved inorganic nitrogen and dissolved inorganic phosphorus, bottom total suspended solids, and bottom dissolved oxygen (Table 4-38). No degrading trends were observed. Surface and bottom water temperature and surface water salinity showed increasing trends. Trends for the remaining parameters were not significant.

2. Water quality for SAV

Improving trends were detected in surface total nitrogen, dissolved inorganic nitrogen, total phosphorus, dissolv1ed inorganic phosphorus and the percentage of light at the leaf surface at 0.5 meters (Table 4-40). Relative status of all parameters was poor except for surface total suspended solids and chlorophyll *a* for which the relative status was fair and good, respectively. Most parameters failed to meet the SAV habitat requirements except for chlorophyll *a* and total suspended solids which met the requirements (Table 4-41).

3. Living resources

This is one of the most polluted rivers in Virginia with a phytoplankton composition that is dominated by flora common to the Chesapeake Bay. The status for total phytoplankton biomass, the biomass to cell abundance ratio, and species diversity is poor. Cyanobacteria biomass status is poor, with degrading trends in both cyanobacteria biomass and abundance. Total phytoplankton biomass and abundance are increasing, although the status of diatoms is fair (diatoms do have a improving trend). Favorable status is present for the chlorophytes, autotrophic picoplankton, productivity, and the picoplankton to eukaryote ratio. Although there are several positive signs, the phytoplankton populations remain under stress conditions (Figure 4-14).

Microzooplankton trends for the Elizabeth River were degrading for copepod nauplii and decreasing for most other parameters. Although rotifer abundance status was good, the poor copepod nauplii status and decreasing trends in most microzooplankton parameters reflected the generally poor status of most water quality parameters (Figure 4-15).

Benthic community status was degraded with an improving trend in the B-IBI at station SBE5. The improving trend in the B-IBI was the result of trends in nearly all metrics measuring the health of benthic community composition (Figure 4-17).

L. Eastern Branch of the Elizabeth River (EBEMH - Eastern Branch)

1. Water quality for living resources

Status was good in the Elizabeth River Eastern Branch segment only for surface chlorophyll *a* (Table 4-43). Status was fair for surface and bottom total nitrogen, bottom dissolved inorganic nitrogen, surface and bottom total phosphorus, surface and bottom total suspended solids, and bottom dissolved oxygen. Status was poor for surface dissolved inorganic nitrogen, surface and bottom dissolved inorganic phosphorus, and secchi depth. Improving trends were detected in the Elizabeth River Eastern Branch segment for surface and bottom total nitrogen and total phosphorus, surface and bottom dissolved inorganic nitrogen and dissolved inorganic phosphorus, and bottom dissolved oxygen (Table 4-42). No degrading trends were observed. Surface water salinity showed an increasing trend. Trends for the remaining parameters were not significant.

2. Water quality for SAV

Improving trends were detected in surface total nitrogen, dissolved inorganic nitrogen, total phosphorus, dissolv1ed inorganic phosphorus and the percentage of light at the leaf surface at 0.5 meters (Table 4-44). Relative status of most parameters was poor except for surface total nitrogen and chlorophyll *a* for which the relative status was fair and good, respectively. Most parameters either failed to meet the SAV habitat requirements or were borderline except for chlorophyll *a* and total suspended solids which met the requirements (Table 4-45).

3. Living resources

Phytoplankton and zooplankton monitoring is not conducted within this segment.

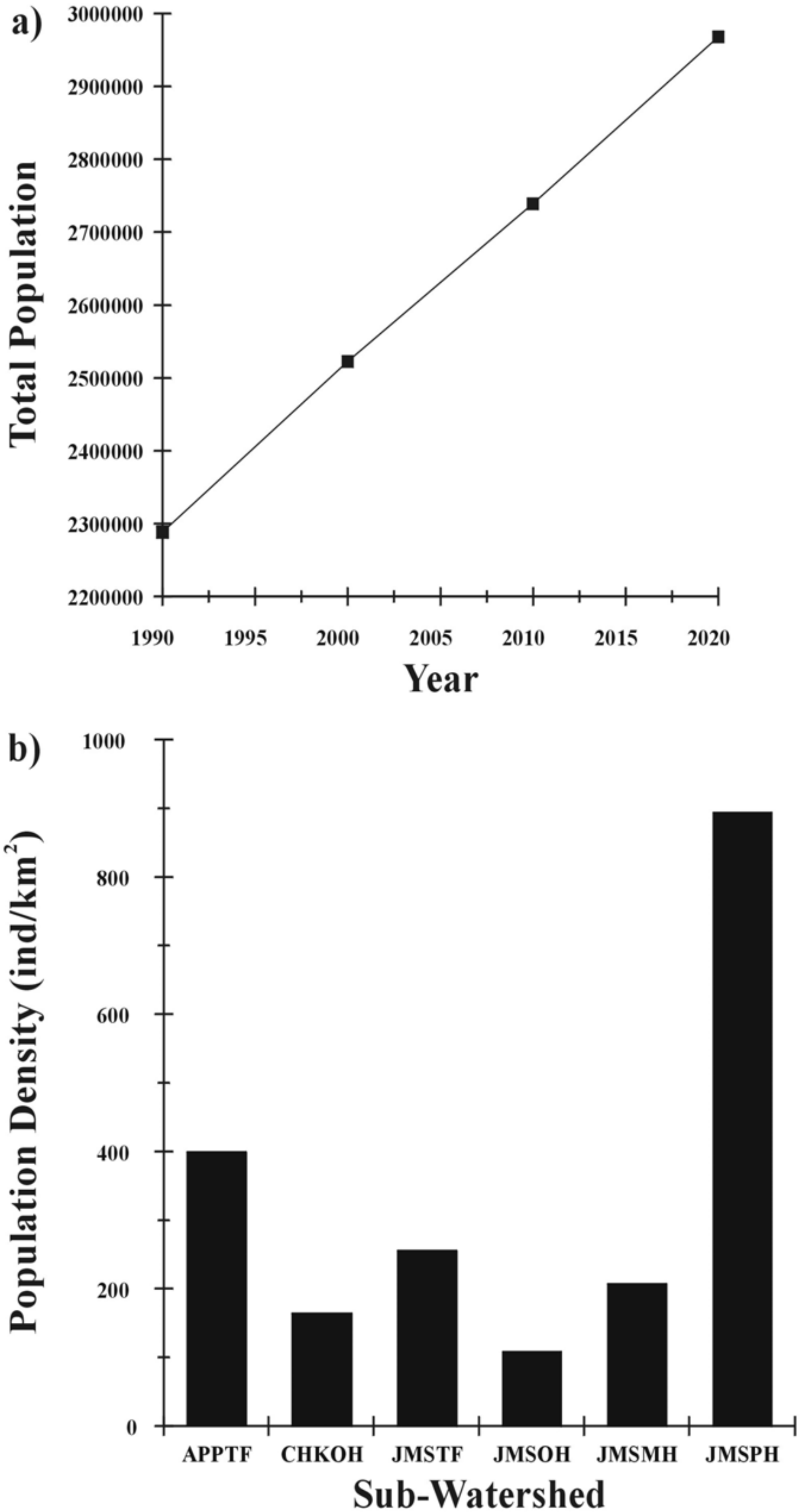


Figure 4-1. Patterns in a) total and project total watershed population over time and b) population density between sub-watersheds within the James River basin.

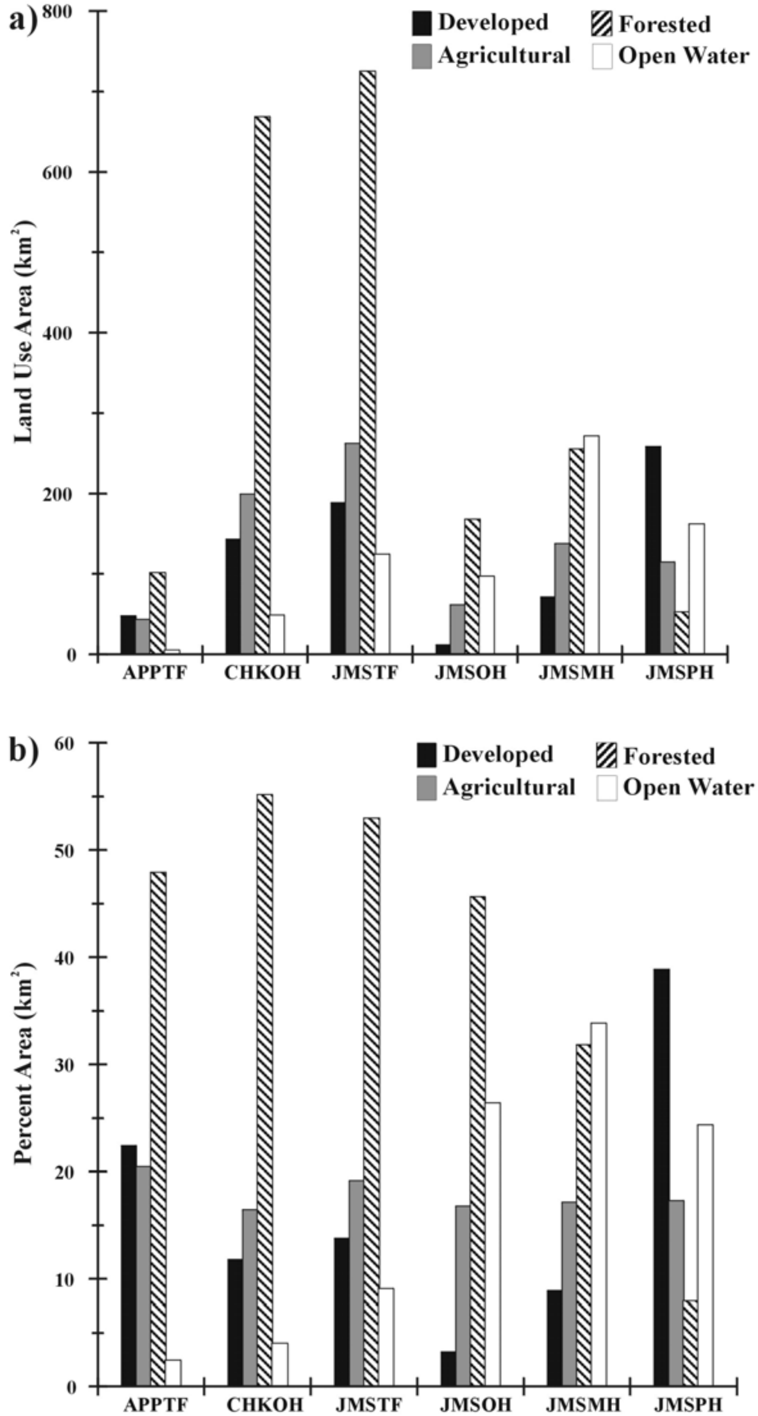


Figure 4-2. Differences in a) total area and b) percentages of land-use types between sub-watersheds of the James River for 1999. Data presented were provided by the USEPA, Chesapeake Bay Program Office.

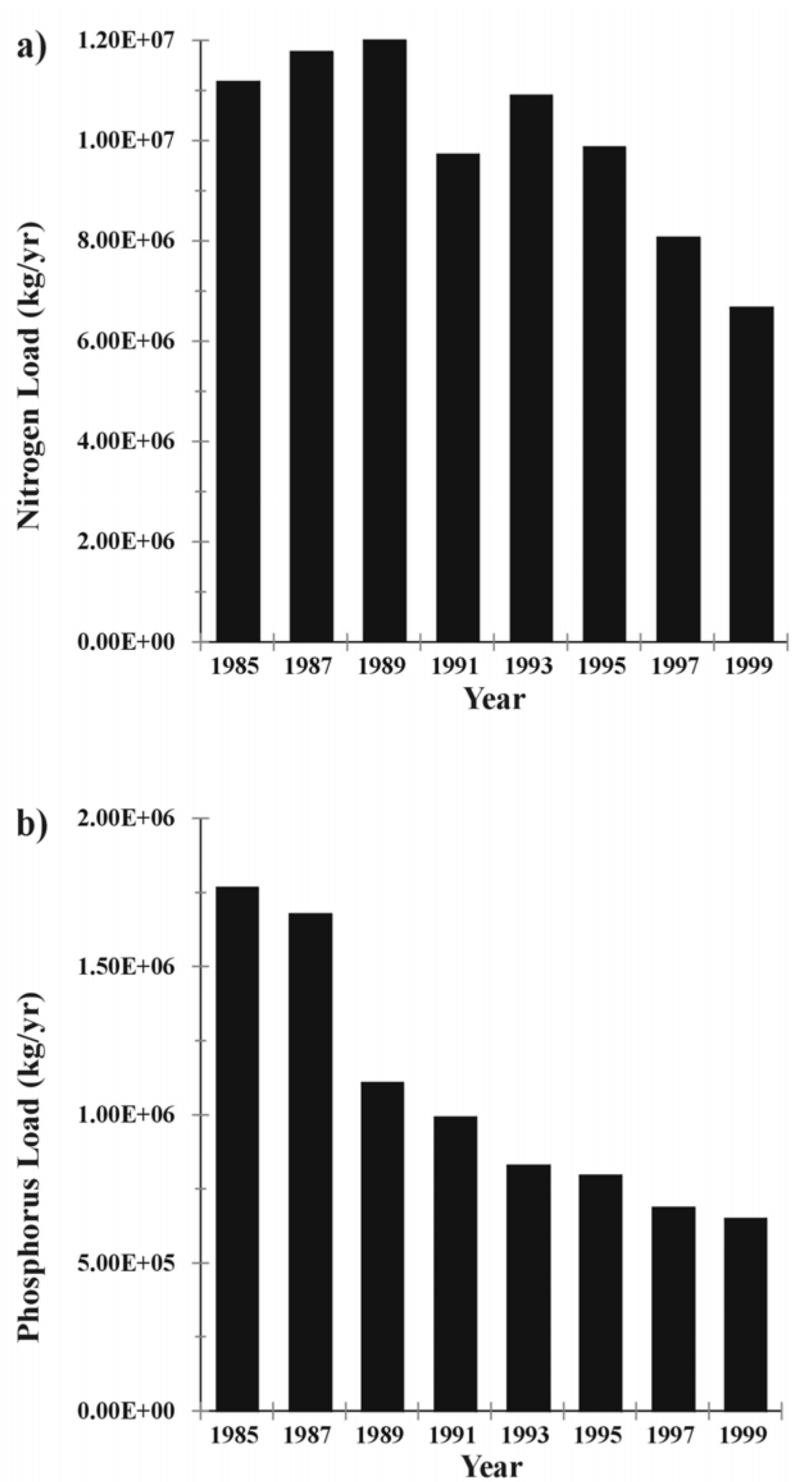


Figure 4-3. Non-point source loadings of a) nitrogen, b) phosphorus, and c) sediments by source for the James River in 2000. Data generated using the USEPA Chesapeake Bay Watershed Model.

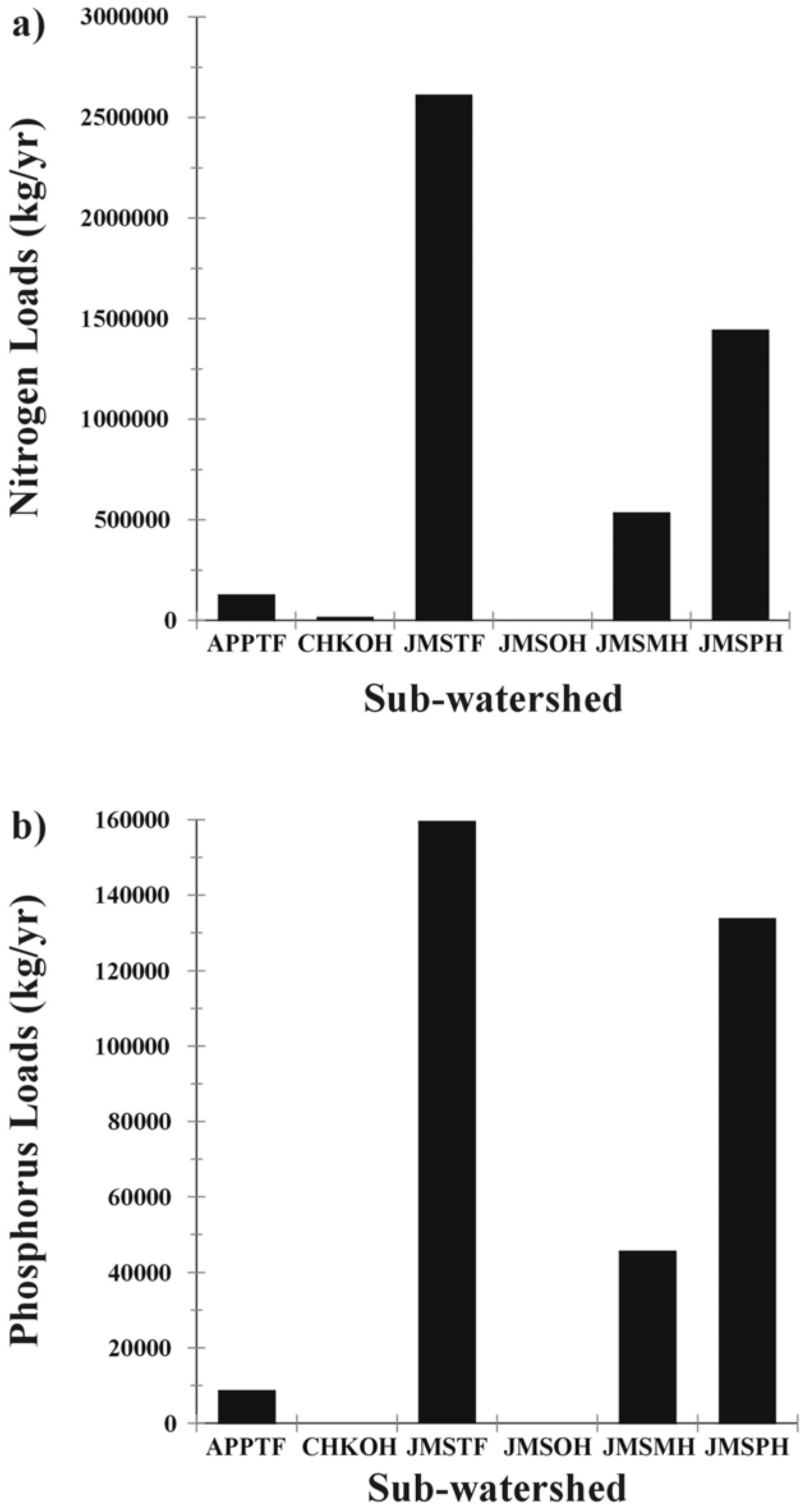


Figure 4-5. Spatial patterns in point source a) nitrogen and b) phosphorus loadings in the James River for 1999.

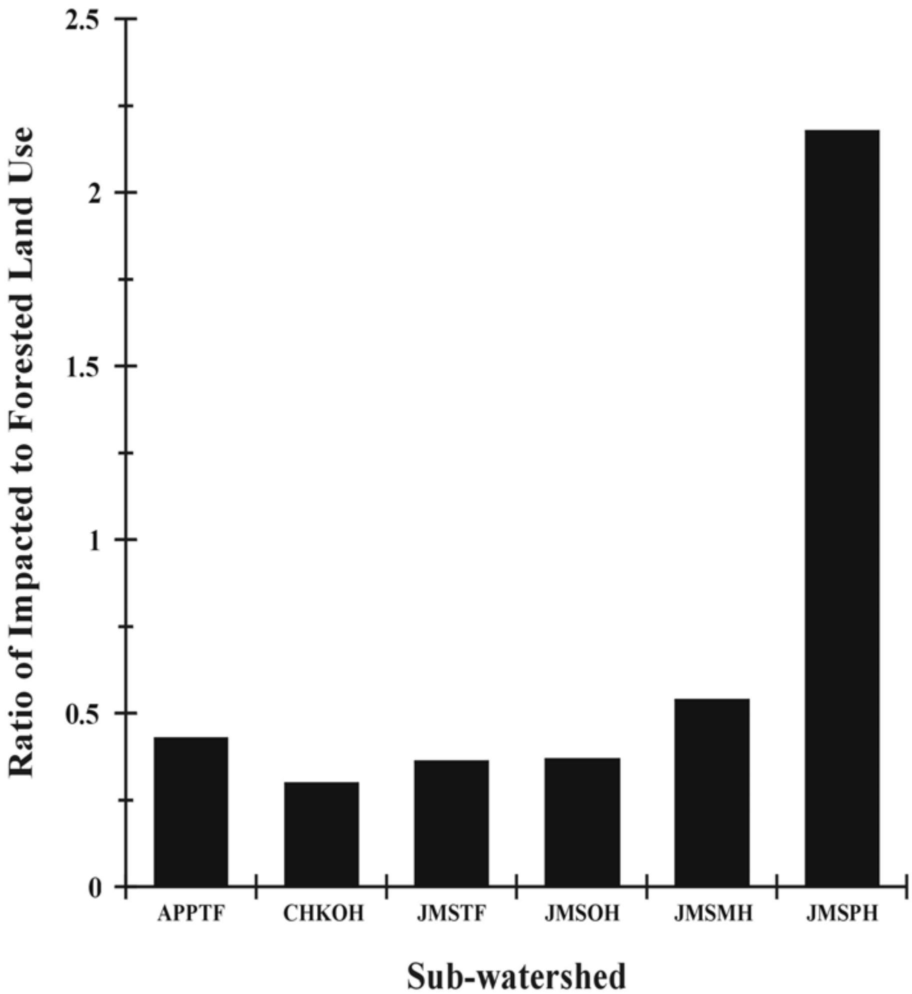


Figure 4-6. Spatial patterns in the ratio of impacted (agricultural and urban) land use to forested land use between sub-watersheds of the James River basin in 2000.

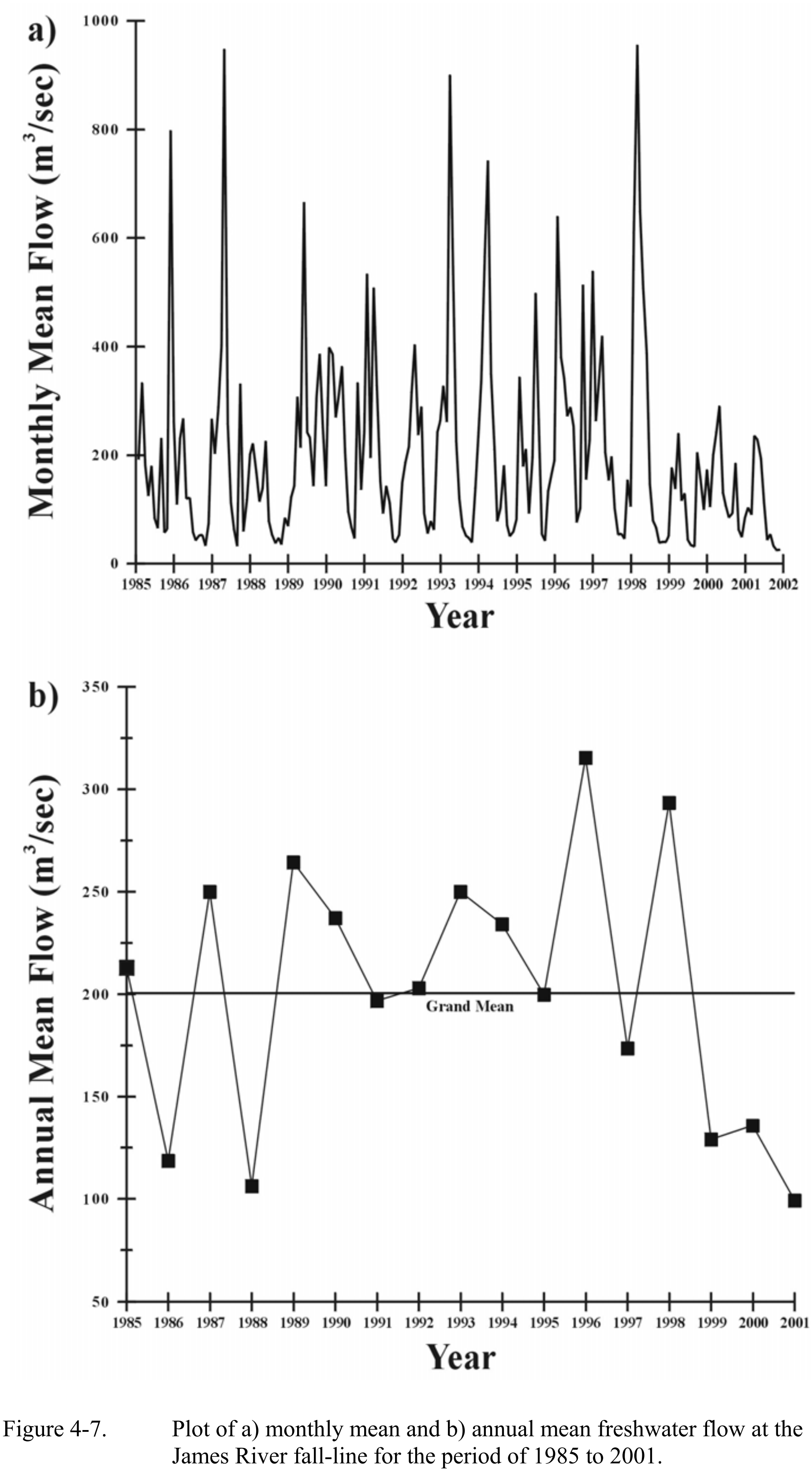
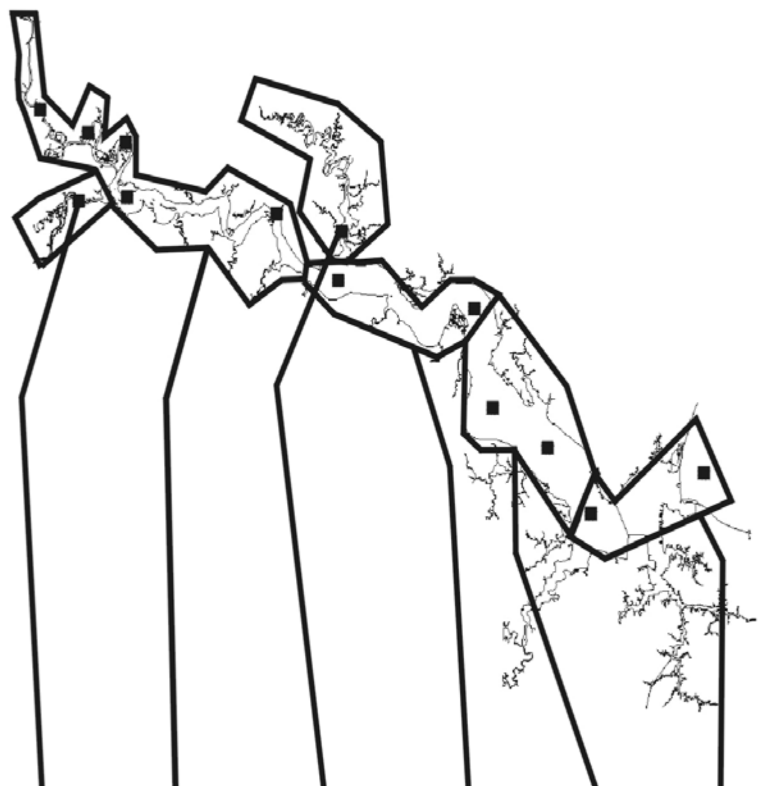


Figure 4-7. Plot of a) monthly mean and b) annual mean freshwater flow at the James River fall-line for the period of 1985 to 2001.

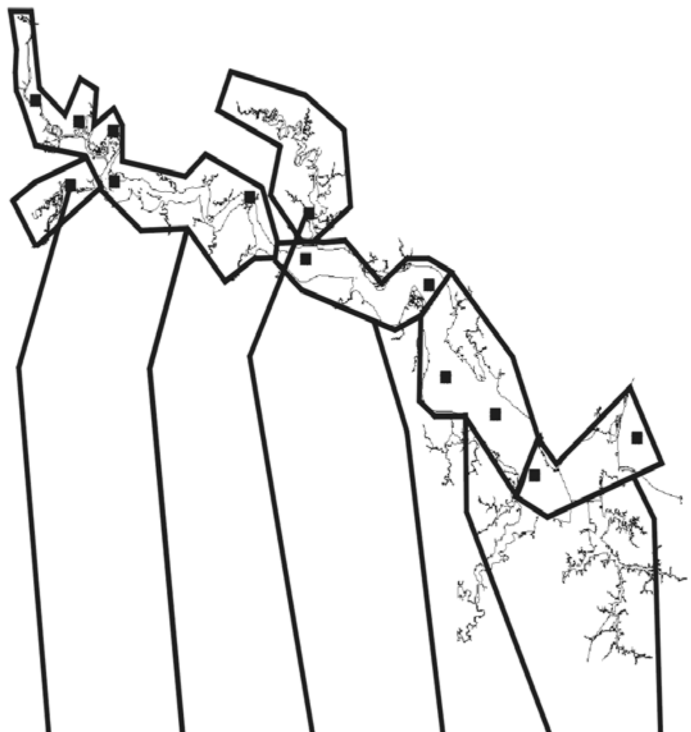
Status (1999 to 2001)	Trends (1985 to 2001)
○ Good	▲ Increasing (Degrading)
◍ Fair	△ Increasing (Improving)
● Poor	▽ Decreasing (Improving)
	▼ Decreasing (Degrading)
	NS Not significant
	* Season specific trend



Parameter	Appomatox		Upper James		Chickahominy		Middle James		Lower James		River Mouth	
STN	○	NS	○	▽	○	▽	○	NS	○	▲	◍	▲
BTN	○	NS	○	▽	○	▽	○	▲	○	▲	◍	▲
SDIN	○	NS	○	▽	○	NS	○	▽	○	NS	◍	NS
BDIN	○	NS	○	▽	○	NS	○	▽	○	NS	○	NS
STP	◍	NS	◍	▽	◍	▲	○	▲	●	▲	●	NS
BTP	◍	▲	◍	▽	○	▲	◍	▲	●	▲	●	NS
SDIP	○	▽	◍	▽	◍	NS	●	NS	●	NS	●	NS
BDIP	○	▽	◍	▽	◍	NS	●	NS	●	NS	◍	NS

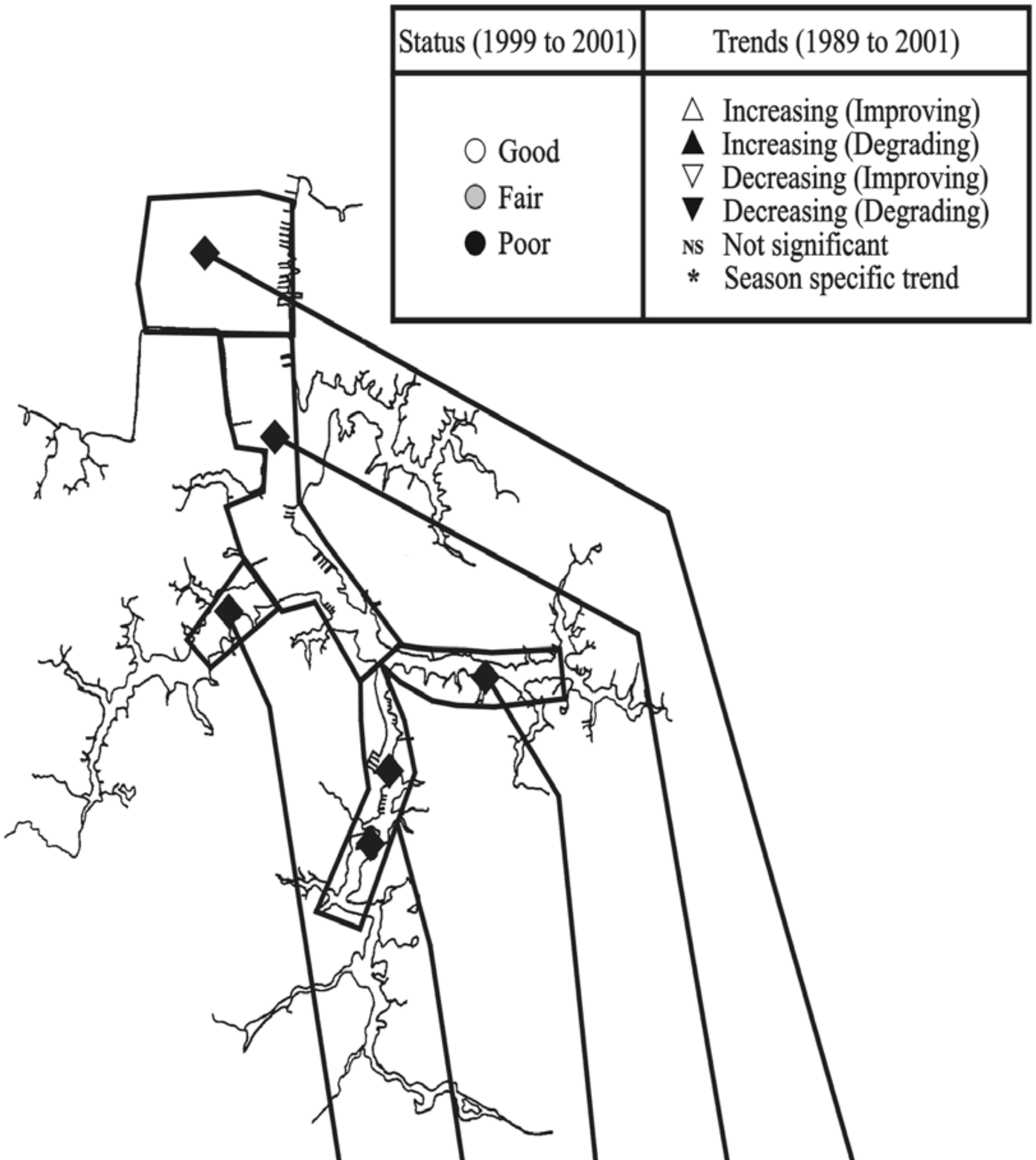
Figure 4-8. Map of the James River basin showing summaries of the status and trend analyses for each segment. Abbreviations for each parameter are: TN= total nitrogen; DIN=dissolved inorganic nitrogen; TP=total phosphorus; DIP= dissolved inorganic phosphorus. The prefixes S and B refer to surface and bottom measurements, respectively. All parameters shown were corrected for potential method effects associated with changes to analytical techniques that occurred in 1994.

Status (1999 to 2001)	Trends (1985 to 2001)
○ Good ◍ Fair ● Poor	▲ Increasing (Degrading) △ Increasing (Improving) ▽ Decreasing (Improving) ▼ Decreasing (Degrading) NS Not significant * Season specific trend



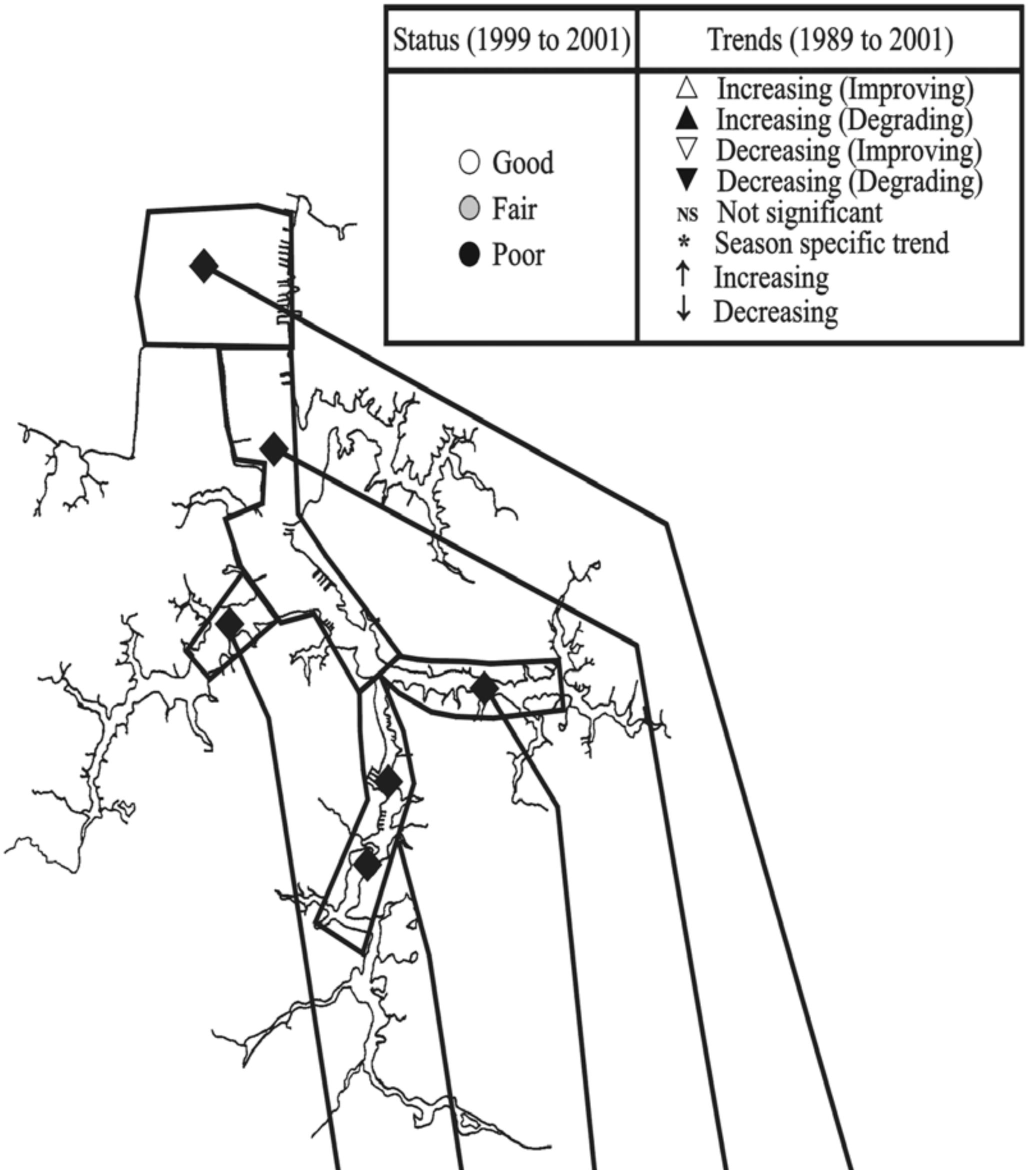
Parameter	Appomattox	Upper James	Chickahominy	Middle James	Lower James	River Mouth
SCHLA	● NS	● ▲	● NS	○ NS	○ NS	● NS
STSS	● NS	◍ NS	◍ ▲	◍ ▽	● NS	◍ ▲
BTSS	◍ NS	◍ ▲	◍ ▲	● NS	● ▲	◍ NS
SECCHI	◍ NS	◍ NS	○ NS	○ NS	● NS	● ▼
BDO	○ △	○ △	○ NS	○ NS	○ NS	○ △
SWTEMP	↑	NS	NS	NS	NS	NS
BWTEMP	↑	NS	NS	NS	NS	↑
SSALIN	NS	NS	NS	↑	NS	NS
BSALIN	NS	NS	NS	↑	NS	↓

Figure 4-9. Map of the James River basin showing summaries of the status and trend analyses for each segment. Abbreviations for each parameter are: CHLA=chlorophyll a; TSS=total suspended solids; SECCHI=secchi depth; DO=dissolved oxygen; WTEMP=water temperature; SALIN=salinity. The prefixes S and B refer to surface and bottom measurements, respectively.



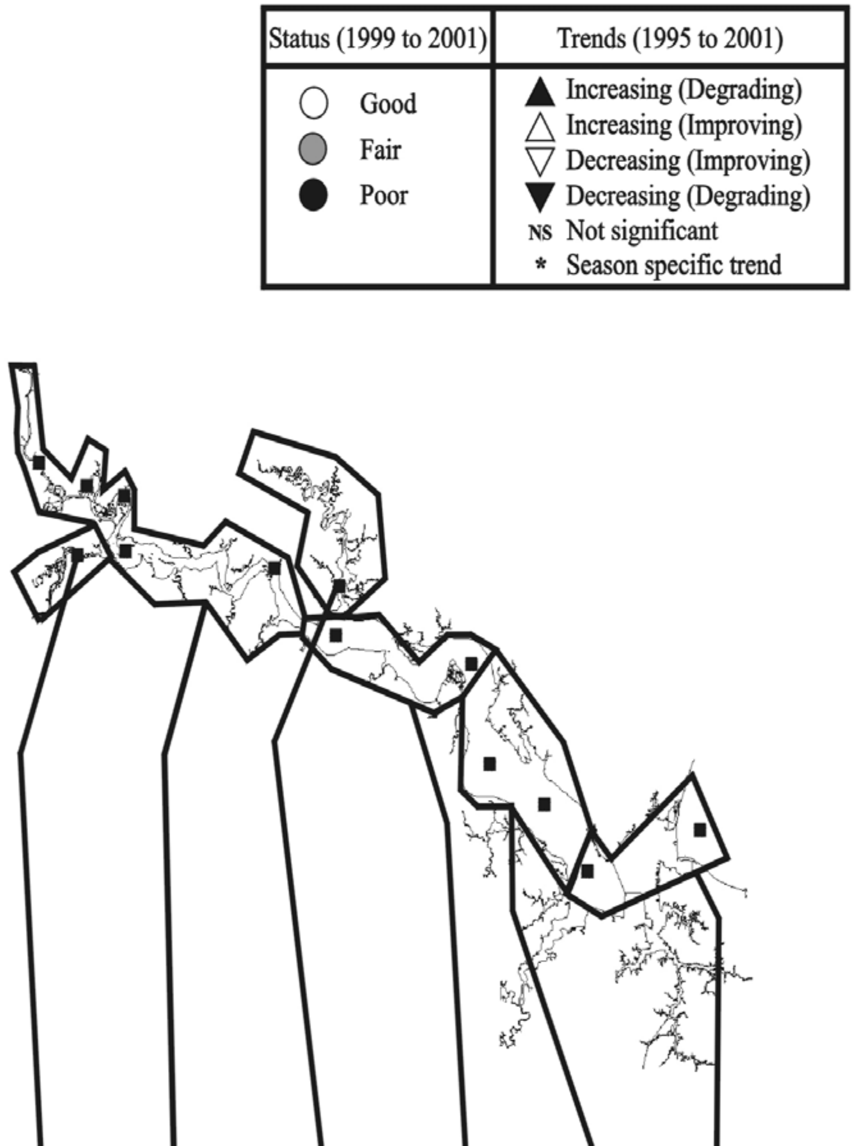
Parameter	Western Branch	Southern Branch	Eastern Branch	Elizabeth River Mainstem	Elizabeth River Mouth
STN	○ ▽	● ▽	◍ ▽	○ ▽	● ▲
BTN	○ ▽	● ▽	◍ ▽	○ ▽	● ▲
SDIN	○ ▽	● ▽	● ▽	◍ ▽	● NS
BDIN	○ ▽	● ▽	◍ ▽	○ ▽	● NS
STP	● ▽	● ▽	◍ ▽	● ▽	● ▲
BTP	● ▽	● ▽	◍ ▽	● ▽	● ▲
SDIP	● ▽	● ▽	● ▽	● ▽	● NS
BDIP	● ▽	● ▽	● ▽	● ▽	● NS

Figure 4-10. Map of the Elizabeth River basin showing summaries of the status and trend analyses for each segment for the period after the method corrections were initiated (1995-2001). Abbreviations for each parameter are: TN= total nitrogen; DIN=dissolved inorganic nitrogen; TP=total phosphorus; DIP= dissolved inorganic phosphorus. The prefixes S and B refer to surface and bottom measurements, respectively.



Parameter	Western Branch		Southern Branch		Eastern Branch		Elizabeth River Mainstem		Elizabeth River Mouth	
SCHLA	●	▽	○	NS	○	NS	◐	NS	●	NS
STSS	●	NS	◐	NS	◐	NS	●	NS	◐	▽
BTSS	●	NS	○	▽	◐	NS	●	NS	●	NS
SECCHI	●	NS	●	NS	●	NS	●	NS	●	▼
BDO	○	△	◐	△	◐	△	○	△	○	NS
SWTEMP		NS		↑		NS		NS		NS
BWTEMP		NS		↑		NS		↑		NS
SSALIN		↑		↑		↑		↑		NS
BSALIN		↑		NS		NS		NS		NS

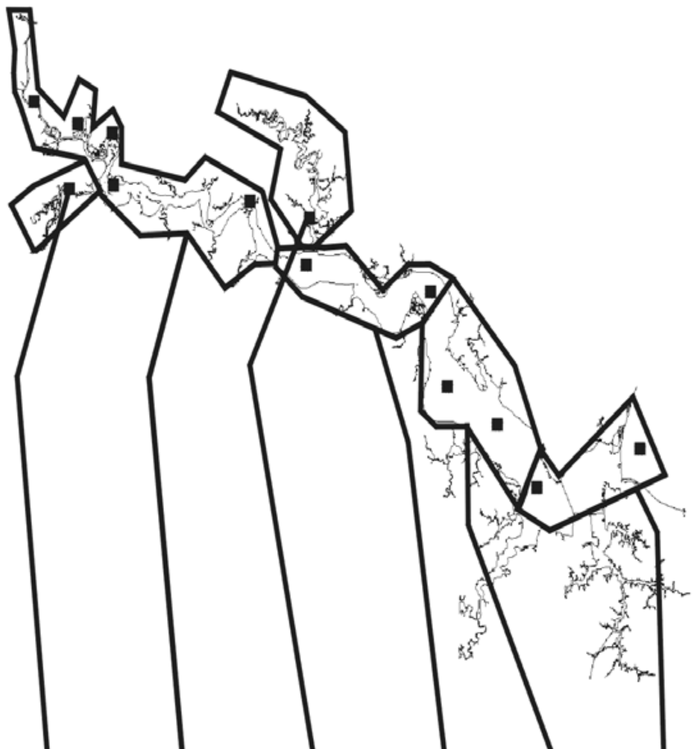
Figure 4-11. Map of the Elizabeth River basin showing summaries of the status and trend analyses for each segment for the period after the method corrections were initiated (1995-2001). Abbreviations for each parameter are: CHLA=chlorophyll a; TSS=total suspended solids; SECCHI=secchi depth; DO= dissolved oxygen; WTEMP=water temperature; SALIN=salinity. The prefixes S and B refer to surface and bottom measurements, respectively.



Parameter	Appomatox	Upper James	Chickahominy	Middle James	Lower James	River Mouth
STN	○ NS	○ NS	○ NS	○ ▽	○ ▽	◍ ▽
BTN	○ NS	○ NS	○ NS	○ ▽	○ NS	◍ NS
SDIN	○ NS	○ ▽	○ NS	○ NS	○ NS	◍ NS
BDIN	○ NS	○ ▽	○ NS	○ ▽	○ NS	○ NS
STP	◍ NS	◍ NS	◍ NS	○ NS	● NS	● ▽
BTP	◍ NS	◍ NS	○ NS	◍ ▽	● NS	● ▽
SDIP	○ ▽	◍ ▽	◍ NS	● NS	● NS	● NS
BDIP	○ ▽	◍ ▽	◍ NS	● NS	● NS	◍ NS

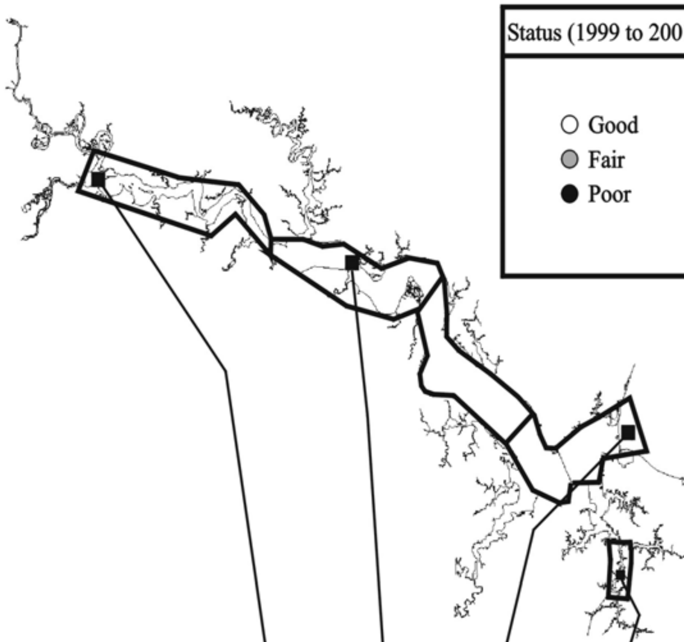
Figure 4-12. Map of the James River basin showing summaries of the status and trend analyses for each segment for the period after the method corrections were initiated (1995-2001). Abbreviations for each parameter are: TN= total nitrogen; DIN=dissolved inorganic nitrogen; TP=total phosphorus; DIP= dissolved inorganic phosphorus. The prefixes S and B refer to surface and bottom measurements, respectively.

Status (1999 to 2001)	Trends (1995 to 2001)
○ Good	▲ Increasing (Degrading)
◐ Fair	△ Increasing (Improving)
● Poor	▽ Decreasing (Improving)
	▼ Decreasing (Degrading)
	NS Not significant
	* Season specific trend



Parameter	Appomattox	Upper James	Chickahominy	Middle James	Lower James	River Mouth
SCHLA	● ▲	● ▲	● NS	○ NS	○ NS	● NS
STSS	● NS	◐ NS	◐ NS	◐ NS	● NS	◐ NS
BTSS	◐ NS	◐ NS	◐ NS	● NS	● NS	◐ NS
SECCHI	◐ ▼	◐ ▼	○ ▼	○ NS	● NS	● NS
BDO	○ NS	○ NS	○ NS	○ NS	○ NS	○ △
SWTEMP	NS	NS	NS	NS	NS	NS
BWTEMP	NS	NS	NS	NS	NS	↑
SSALIN	NS	NS	↑	↑	↑	↑
BSALIN	NS	NS	↑	↑	NS	NS

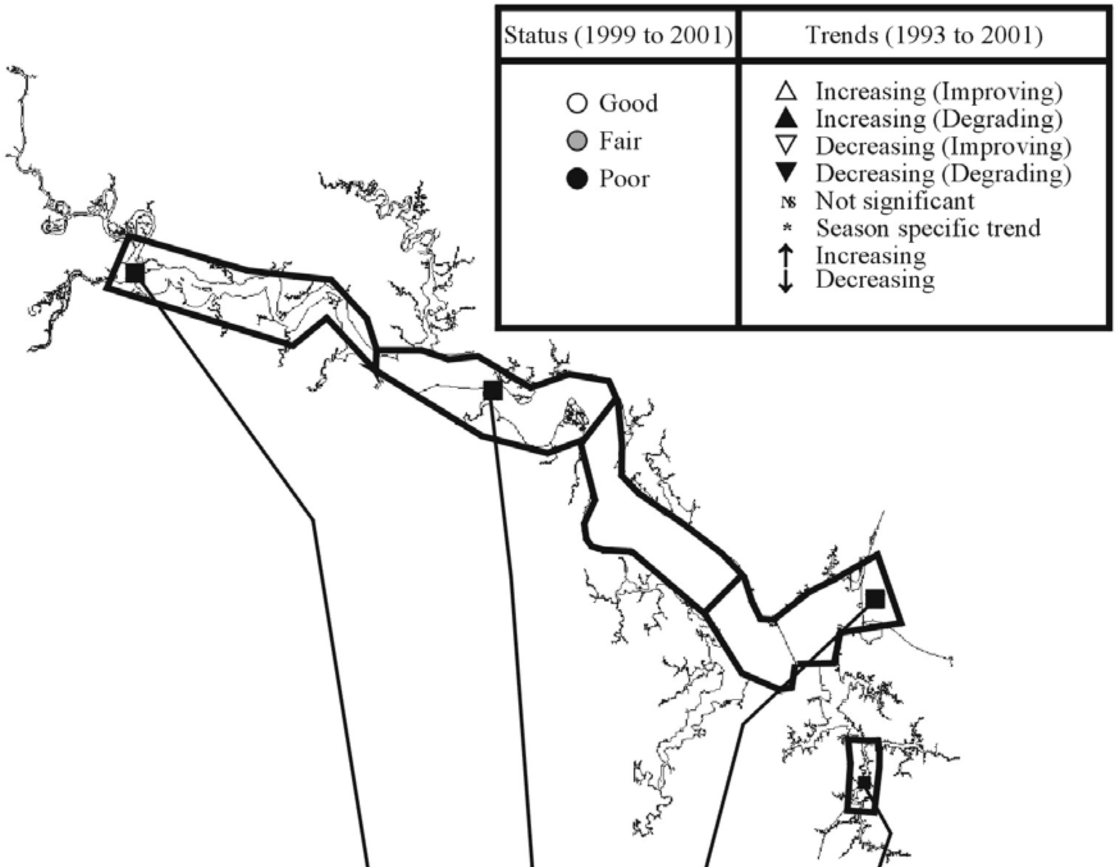
Figure 4-13. Map of the James River basin showing summaries of the status and trend analyses for each segment for the period after the method corrections were initiated (1995-2001). Abbreviations for each parameter are: CHLA=chlorophyll a; TSS=total suspended solids; SECCHI=secchi depth; DO= dissolved oxygen; WTEMP=water temperature; SALIN=salinity. The prefixes S and B refer to surface and bottom measurements, respectively.



Status (1999 to 2001)	Trends (1985 to 2001)
○ Good ◍ Fair ● Poor	△ Increasing (Improving) ▲ Increasing (Degrading) ▽ Decreasing (Improving) ▼ Decreasing (Degrading) NS Not significant * Season specific trend ↓ Decreasing ↑ Increasing

	TF5.5	RET5.2	LE5.5	SBE5
Total Abundance	↑	↑	NS	↑
Total Biomass	○ ↑	◍ ↑	● ↑	● ↑
Biomass to Abundance	● △	● △	● △	● NS
Margalef Diversity Index	● △	◍ NS	● NS	● NS
Productivity	● NS	○ ▽	◍ ▽	○ ▽
Diatom Biomass	○ △	○ △	◍ △	◍ △
Dinoflagellate Biomass	● NS	● NS	◍ NS	○ NS
Cyanophyte Biomass	● ▲	● ▲	● ▲	◍ ▲
Chlorophyte Biomass	○ △	○ △	○ △	○ △
Picoplankton Biomass	○ ▽	○ ▽	○ ▽	○ ▽
Cryptophyte Biomass	△	△	NS	NS
Procaryote to Eucaryote Biomass	○ NS	○ NS	○ NS	○ NS
Cyanophyte Abundance	▲	▲	▲	▲

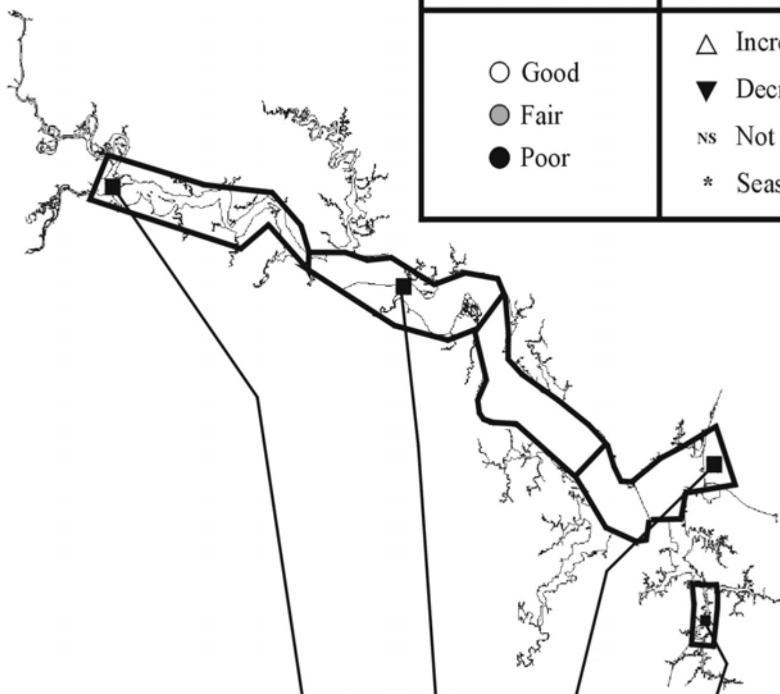
Figure 4-14. Map of the James River basin showing summaries of the status and trend analyses for phytoplankton bioindicators for each segment.



	TF5.5	RET5.2	LE5.5	SBE5
Total Abundance	NS	NS	NS	↓
Total Biomass	↑	NS	NS	↓
Copepod Nauplii Abundance	○ NS	◍ NS	● ▼	● NS
Rotifer Abundance	● ▲	○ NS	● ▲	○ NS
Oligotrich Abundance	NS	NS	NS	↓
Cladoceran Abundance	NS	NS	NS	NS
Tintinnid Abundance	↑	NS	NS	↓
Polychaeta Larvae Abundance	NS	NS	↓	↓

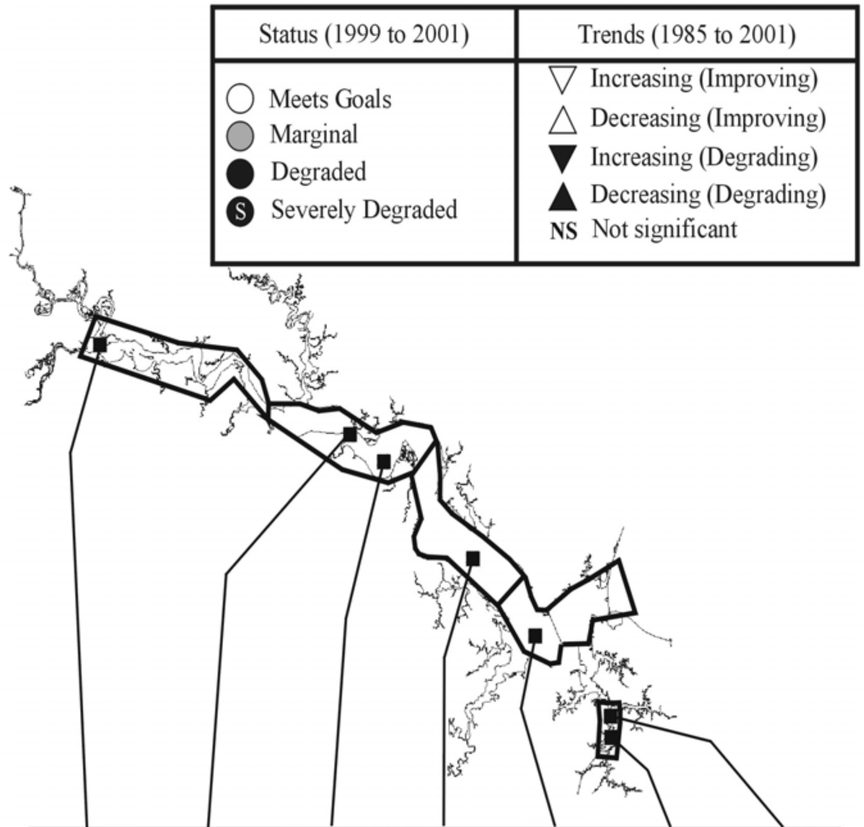
Figure 4-15. Map of the James River basin showing summaries of the status and trend analyses for microzooplankton bioindicators for each segment.

Status (1997 to 1999)	Trends (1985 to 1999)
○ Good	△ Increasing (Improving)
◍ Fair	▼ Decreasing (Degrading)
● Poor	NS Not significant
	* Season specific trend



	TF5.5	RET5.2	LE5.5	SBE5
Total Abundance	○ NS	◍ NS	● ▼	● △
Margalef Diversity Index	○ △	○ △	○ ▼	◍ ▼
Shannon Wiener Index	○ NS	○ △	◍ ▼	◍ ▼
Holoplankton Abundance	NS	NS	▼	△
Meroplankton Abundance	NS	NS	▼	NS
Calanoid Abundance	△	NS	▼	△
Cyclopoid Abundance	NS	NS	▼	NS
Cladoceran Abundance	NS	NS	▼	NS
Crab Zoea Abundance	NS	NS	▼	NS
Acartia tonsa	▼	▼*	▼	△
Eurytemora spp.	NS	NS	NS	NS
Bosmina longirostis	NS	NS	NS	NS

Figure 4-16. Map of the James River basin showing summaries of the status and trend analyses for mesozooplankton bioindicators for each segment.



	TF5.5	RET5.2	LE5.1	LE5.2	LE5.4	SBE5	SBE2
Benthic IBI	○ △	◍ △	○ **NS**	◍ **NS**	○ **NS**	● △	● **NS**
Total Abundance	△	**NS**	**NS**	△	**NS**	△	△
Total Biomass	△	**NS**	**NS**	**NS**	▼	△	**NS**
Pollution Sensitive Species Abundance (%)	△	△	**NS**	△	**NS**	△	△
Pollution Indicative Species Abundance (%)	▽	**NS**	**NS**	**NS**	▽	▽	▽
Pollution Sensitive Species Biomass (%)	△	**NS**	**NS**	**NS**	**NS**	△	△
Pollution Indicative Species Biomass (%)	▽	**NS**	**NS**	**NS**	▽	▽	▽
Shannon-Weiner Diversity Index	**NS**	△	△	**NS**	**NS**	△	**NS**

Figure 4-17. Map of the James River basin showing summaries of the status and trend analyses for benthic bioindicators for each segment.

Table 4-1. Water quality trends at James RIM stations 2026000 (James River at Bent Creek) 2029000 (James River at Scottsville), 2035000 (James River at Cartersville), 2041650 (Appomattox River at Matoaca). A "*" next to the parameter name indicates the parameter was not log-transformed prior to analysis. In the Data Type column, FAC refers to flow adjusted concentrations, FWC refers to flow weighted concentrations, and LOAD refers to loadings.

River	Station	Parameter	DataType	Status	Slope	pValue	Direction
James River at Cartersville	2035000	FLOW	FLOW	3747.50	-0.0306	0.0121	DECREASING
James River at Cartersville	2035000	TN	FAC	--	-0.0125	0.0062	IMPROVING
James River at Cartersville	2035000	TN	FWC	1.127	-0.0227	0.0002	IMPROVING
James River at Cartersville	2035000	TN	LOAD	0.899	-0.0533	0.0030	IMPROVING
James River at Cartersville	2035000	NO23F	FWC	0.313	-0.0556	0.0001	IMPROVING
James River at Cartersville	2035000	NO23F	LOAD	0.266	-0.0862	0.0001	IMPROVING
James River at Cartersville	2035000	NO23F	FAC	--	-0.0404	0.0000	IMPROVING
James River at Cartersville	2035000	TP	FAC	--	-0.0423	0.0000	IMPROVING
James River at Cartersville	2035000	TP	FWC	0.213	-0.0514	0.0001	IMPROVING
James River at Cartersville	2035000	TP	LOAD	0.153	-0.0820	0.0001	IMPROVING
James River at Cartersville	2035000	PO4F	FWC	0.084	-0.0801	0.0001	IMPROVING
James River at Cartersville	2035000	PO4F	FAC	--	-0.0778	0.0000	IMPROVING
James River at Cartersville	2035000	PO4F	LOAD	0.071	-0.1107	0.0001	IMPROVING
James River at Cartersville	2035000	TSS	LOAD	24.79	-0.0891	0.0159	IMPROVING
James River at Cartersville	2035000	TSS	FWC	30.90	-0.0585	0.0206	IMPROVING
James River at Bent Creek	2026000	TN	FAC	--	-0.0115	0.0254	IMPROVING
James River at Bent Creek	2026000	TN	LOAD	0.878	-0.0300	0.0053	IMPROVING
James River at Bent Creek	2026000	TN	FWC	0.460	-0.0154	0.0001	IMPROVING
James River at Bent Creek	2026000	TNH4	FAC	--	-0.0451	0.0000	IMPROVING
James River at Bent Creek	2026000	TNH4	FWC	0.029	-0.0460	0.0001	IMPROVING
James River at Bent Creek	2026000	TNH4	LOAD	0.056	-0.0606	0.0001	IMPROVING
James River at Bent Creek	2026000	TKN	FAC	--	0.0246	0.0001	DEGRADING
James River at Bent Creek	2026000	TKN	FWC	0.306	0.0210	0.0001	DEGRADING
James River at Bent Creek	2026000	NO23W	FWC	0.146	-0.0636	0.0001	IMPROVING
James River at Bent Creek	2026000	NO23W	FAC	--	-0.0583	0.0000	IMPROVING
James River at Bent Creek	2026000	NO23W	LOAD	0.276	-0.0782	0.0001	IMPROVING
James River at Bent Creek	2026000	NO3W	FAC	--	-0.0619	0.0000	IMPROVING
James River at Bent Creek	2026000	NO3W	LOAD	0.256	-0.0823	0.0001	IMPROVING
James River at Bent Creek	2026000	NO3W	FWC	0.139	-0.0677	0.0001	IMPROVING
James River at Bent Creek	2026000	TP	LOAD	0.136	-0.0945	0.0001	IMPROVING
James River at Bent Creek	2026000	TP	FWC	0.075	-0.0798	0.0001	IMPROVING
James River at Bent Creek	2026000	TP	FAC	--	-0.0800	0.0000	IMPROVING
James River at Scottsville	2029000	TN	FWC	0.426	-0.0174	0.0001	IMPROVING
James River at Scottsville	2029000	TN	LOAD	0.891	-0.0311	0.0102	IMPROVING
James River at Scottsville	2029000	TN	FAC	--	-0.0137	0.0190	IMPROVING
James River at Scottsville	2029000	TNH4	FWC	0.024	-0.0629	0.0001	IMPROVING
James River at Scottsville	2029000	TNH4	FAC	--	-0.0628	0.0000	IMPROVING
James River at Scottsville	2029000	TNH4	LOAD	0.048	-0.0766	0.0001	IMPROVING
James River at Scottsville	2029000	TKN	FAC	--	0.0127	0.0946	DEGRADING
James River at Scottsville	2029000	TKN	FWC	0.266	0.0101	0.0368	IMPROVING
James River at Scottsville	2029000	NO23W	FWC	0.184	-0.0410	0.0001	IMPROVING
James River at Scottsville	2029000	NO23W	LOAD	0.388	-0.0547	0.0001	IMPROVING
James River at Scottsville	2029000	NO23W	FAC	--	-0.0344	0.0001	IMPROVING
James River at Scottsville	2029000	NO3W	FAC	--	-0.0427	0.0000	IMPROVING
James River at Scottsville	2029000	NO3W	LOAD	0.349	-0.0641	0.0001	IMPROVING
James River at Scottsville	2029000	NO3W	FWC	0.161	-0.0504	0.0001	IMPROVING
James River at Scottsville	2029000	TP	FWC	0.073	-0.0613	0.0001	IMPROVING
James River at Scottsville	2029000	TP	LOAD	0.144	-0.0749	0.0001	IMPROVING
James River at Scottsville	2029000	TP	FAC	--	-0.0597	0.0000	IMPROVING
Appomattox River at Matoaca	2041650	FLOW	FLOW	622.40	-0.0416	0.0286	IMPROVING
Appomattox River at Matoaca	2041650	TN	LOAD	0.820	-0.0418	0.0381	IMPROVING
Appomattox River at Matoaca	2041650	NO23F	LOAD	0.196	-0.0479	0.0037	IMPROVING
Appomattox River at Matoaca	2041650	NO23F	FAC	--	-0.0203	0.0109	IMPROVING
Appomattox River at Matoaca	2041650	TP	LOAD	0.060	-0.0498	0.0374	IMPROVING
Appomattox River at Matoaca	2041650	PO4F	FWC	0.022	-0.0221	0.0001	IMPROVING
Appomattox River at Matoaca	2041650	PO4F	FAC	--	-0.0253	0.0002	IMPROVING
Appomattox River at Matoaca	2041650	PO4F	LOAD	0.013	-0.0636	0.0016	IMPROVING
Appomattox River at Matoaca	2041650	TSS	FAC	--	0.0178	0.0126	DEGRADING

Table 4-2. Water quality status in segment JMSPH (value is the median concentration, secchi depth in meters, chlorophyll *a* in µg/l, all other parameters in mg/l).

Segment	Parameter	Season	SValue	SScore	SStatus	BValue	BScore	BStatus
JMSPH	TN	Annual	0.424	38.3	FAIR	0.428	43.4	FAIR
JMSPH	TN	Spring1	0.409	38.7	GOOD	0.394	38.1	GOOD
JMSPH	TN	Spring2	0.405	38.5	GOOD	0.409	41.5	FAIR
JMSPH	TN	Summer1	0.454	44.1	FAIR	0.463	45.3	FAIR
JMSPH	TN	Summer2	0.460	46.3	FAIR	0.470	42.9	FAIR
JMSPH	DIN	Annual	0.039	41.1	FAIR	0.035	25.6	GOOD
JMSPH	DIN	Spring1	0.040	31.8	GOOD	0.027	51.8	FAIR
JMSPH	DIN	Spring2	0.037	55.6	FAIR	0.049	55.4	FAIR
JMSPH	DIN	Summer1	0.034	47.4	FAIR	0.035	14.8	GOOD
JMSPH	DIN	Summer2	0.033	65.3	POOR	0.040	9.8	GOOD
JMSPH	TP	Annual	0.039	77.0	POOR	0.044	62.1	POOR
JMSPH	TP	Spring1	0.033	78.5	POOR	0.042	65.4	POOR
JMSPH	TP	Spring2	0.040	81.5	POOR	0.044	77.8	POOR
JMSPH	TP	Summer1	0.056	80.6	POOR	0.060	58.1	POOR
JMSPH	TP	Summer2	0.059	81.7	POOR	0.064	51.8	FAIR
JMSPH	DIP	Annual	0.008	69.5	POOR	0.010	59.8	FAIR
JMSPH	DIP	Spring1	0.005	46.9	FAIR	0.006	40.5	GOOD
JMSPH	DIP	Spring2	0.008	47.1	FAIR	0.008	46.1	FAIR
JMSPH	DIP	Summer1	0.013	70.5	POOR	0.016	49.5	FAIR
JMSPH	DIP	Summer2	0.017	75.9	POOR	0.018	43.7	FAIR
JMSPH	CHLA	Annual	8.684	58.6	POOR	-	-	-
JMSPH	CHLA	Spring1	8.453	39.2	GOOD	-	-	-
JMSPH	CHLA	Spring2	8.720	49.7	FAIR	-	-	-
JMSPH	CHLA	Summer1	11.211	79.9	POOR	-	-	-
JMSPH	CHLA	Summer2	11.946	78.9	POOR	-	-	-
JMSPH	TSS	Annual	10.185	57.0	FAIR	19.016	49.1	FAIR
JMSPH	TSS	Spring1	15.160	72.0	POOR	23.020	68.9	POOR
JMSPH	TSS	Spring2	15.160	73.8	POOR	23.020	71.6	POOR
JMSPH	TSS	Summer1	12.338	61.6	POOR	19.900	45.8	FAIR
JMSPH	TSS	Summer2	11.685	57.7	FAIR	19.800	40.0	GOOD
JMSPH	SECCHI	Annual	1.150	18.2	POOR	-	-	-
JMSPH	SECCHI	Spring1	1.100	19.4	POOR	-	-	-
JMSPH	SECCHI	Spring2	1.050	6.5	POOR	-	-	-
JMSPH	SECCHI	Summer1	0.975	9.7	POOR	-	-	-
JMSPH	SECCHI	Summer2	0.950	10.5	POOR	-	-	-
JMSPH	DO	Spring1	-	-	-	8.990	-	GOOD
JMSPH	DO	Spring2	-	-	-	7.770	-	GOOD
JMSPH	DO	Summer1	-	-	-	6.863	-	GOOD
JMSPH	DO	Summer2	-	-	-	6.800	-	GOOD

Table 4-3. Water quality trends in segment JMSPH (only significant trends are displayed).

Segment	Parameter	Season	Layer	Baseline	Slope	%Change	%BDL	pValue	Direction
JMSPH	TN*	Annual	S	0.439	0.0090	36.38	0.00	0.0325	DEGRADING
JMSPH	TN*	Spring1	S	0.414	0.0230	93.95	0.00	0.0257	DEGRADING
JMSPH	TN*	Summer1	S	0.415	0.0110	44.29	0.00	0.0286	DEGRADING
JMSPH	TN*	Spring2	S	0.401	0.0160	69.60	0.00	0.0161	DEGRADING
JMSPH	TN*	Annual	B	0.457	0.0110	42.03	0.00	0.0014	DEGRADING
JMSPH	TN*	Spring1	B	0.440	0.0180	70.66	0.00	0.0296	DEGRADING
JMSPH	TN*	Summer1	B	0.448	0.0140	52.69	0.00	0.0284	DEGRADING
JMSPH	TN*	Spring2	B	0.431	0.0150	59.20	0.00	0.0134	DEGRADING
JMSPH	DIN*	Fall	S	0.248	-0.0130	-85.65	3.70	0.0250	IMPROVING
JMSPH	CHLA*	Spring1	S	13.70	-0.323	-40.03	0.00	0.0050	IMPROVING
JMSPH	CHLA*	Summer1	S	4.00	0.331	140.63	0.00	<0.0001	DEGRADING
JMSPH	CHLA*	Summer2	S	3.90	0.398	173.40	0.00	<0.0001	DEGRADING
JMSPH	CHLA*	Annual	B	6.80	0.118	29.48	0.00	0.0280	DEGRADING
JMSPH	CHLA*	Summer1	B	5.40	0.429	135.06	0.00	<0.0001	DEGRADING
JMSPH	CHLA*	Summer2	B	4.20	0.469	189.91	0.00	<0.0001	DEGRADING
JMSPH	TSS	Annual	S	8.30	0.168	34.35	0.01	0.0040	DEGRADING
JMSPH	TSS	Summer1	S	9.80	0.193	33.53	0.00	0.0480	DEGRADING
JMSPH	TSS	Spring2	S	9.70	0.391	68.46	0.00	0.0110	DEGRADING
JMSPH	TSS	Spring1	B	15.50	0.419	45.93	0.00	0.0250	DEGRADING
JMSPH	TSS	Spring2	B	19.30	0.508	44.70	0.00	0.0270	DEGRADING
JMSPH	SECCHI	Annual	S	1.30	-0.01	-17.13	0.00	0.0010	DEGRADING
JMSPH	SECCHI	Summer1	S	1.20	-0.02	-32.87	0.00	<0.0001	DEGRADING
JMSPH	SECCHI	Summer2	S	1.20	-0.03	-35.42	0.00	<0.0001	DEGRADING
JMSPH	DO	Summer1	B	6.00	0.04	12.47	0.00	0.0010	IMPROVING
JMSPH	SALIN	Summer1	S	23.37	-0.15	-10.86	0.00	0.0080	DECREASING
JMSPH	SALIN	Summer2	S	24.03	-0.15	-10.41	0.00	0.0250	DECREASING
JMSPH	SALIN	Annual	B	24.77	-0.17	-11.80	0.00	<0.0001	DECREASING
JMSPH	SALIN	Spring1	B	23.10	-0.17	-12.77	0.00	0.0100	DECREASING
JMSPH	SALIN	Summer1	B	25.21	-0.21	-13.95	0.00	0.0010	DECREASING
JMSPH	SALIN	Spring2	B	23.73	-0.21	-15.21	0.00	0.0020	DECREASING
JMSPH	SALIN	Summer2	B	25.83	-0.21	-13.78	0.00	0.0040	DECREASING
JMSPH	WTEMP	Annual	B	16.95	0.07	6.52	0.00	0.0030	INCREASING
JMSPH	WTEMP	Spring1	B	12.08	0.12	16.94	0.00	0.0070	INCREASING
JMSPH	WTEMP	Summer1	B	23.38	0.06	4.36	0.00	0.0460	INCREASING
JMSPH	WTEMP	Spring2	B	18.18	0.09	8.42	0.00	0.0430	INCREASING
JMSPH	WTEMP	Summer2	B	23.75	0.06	4.52	0.00	0.0460	INCREASING
JMSPH	PLL05	Summer1	S	0.30	-0.005	-27.77	0.00	0.0050	DEGRADING
JMSPH	PLL05	Spring2	S	0.30	-0.005	-25.50	0.00	0.0150	DEGRADING
JMSPH	PLL05	Summer2	S	0.30	-0.004	-22.10	0.00	0.0410	DEGRADING
JMSPH	PLL10	Summer1	S	0.20	-0.004	-37.40	0.00	<0.0001	DEGRADING
JMSPH	PLL10	Spring2	S	0.20	-0.004	-31.45	0.00	0.0090	DEGRADING
JMSPH	PLL10	Summer2	S	0.20	-0.004	-34.85	0.00	0.0050	DEGRADING

Table 4-4. SAV season water quality status in segment JMSPH (value is the median concentration; secchi depth in meters, chlorophyll *a* in µg/l, all other parameters in mg/l).

Segment	Parameter	Value	Score	Status	SAV Goal Value	Habitat Requirement
JMSPH	TN	0.425	39.3	Good	-	-
JMSPH	DIN	0.073	62.9	Poor	0.0381	Pass
JMSPH	TP	0.041	78.4	Poor	-	-
JMSPH	DIP	0.011	80.7	Poor	0.0114	Pass
JMSPH	CHLA	7.14	45.0	Fair	9.1	Pass
JMSPH	TSS	12.68	58.5	Fair	11.0	Pass
JMSPH	SECCHI	1.13	16.2	Poor	-	-
JMSPH	KD	-	-	-	1.50	Borderline
JMSPH	PLL05	-	-	-	0.210	Pass
JMSPH	PLL10	-	-	-	0.108	Fails

Table 4-5. SAV Season Water quality trends in segment JMSPH (only significant trends are displayed).

Segment	Parameter	Season	Layer	Baseline	Slope	%Change	%BDL	pValue	Direction
JMSPH	TN*	SAV1	S	0.410	0.0140	59.66	0.00	0.0012	DEGRADING
JMSPH	TN*	SAV2	S	0.437	0.0150	57.14	0.00	0.0094	DEGRADING
JMSPH	TSS	SAV2	S	6.90	0.269	66.28	0.01	0.0080	DEGRADING
JMSPH	SECCHI	SAV2	S	1.40	-0.01	-15.18	0.00	0.0140	DEGRADING

Table 4-6. Water quality status in segment JMSMH (value is the median concentration, secchi depth in meters, chlorophyll *a* in µg/l, all other parameters in mg/l).

Segment	Parameter	Season	SValue	SScore	SStatus	BValue	BScore	BStatus
JMSMH	TN	Annual	0.471	10.1	GOOD	0.513	12.6	GOOD
JMSMH	TN	Spring1	0.540	11.0	GOOD	0.588	12.6	GOOD
JMSMH	TN	Spring2	0.481	7.7	GOOD	0.551	12.5	GOOD
JMSMH	TN	Summer1	0.462	8.7	GOOD	0.526	13.2	GOOD
JMSMH	TN	Summer2	0.468	9.8	GOOD	0.538	14.8	GOOD
JMSMH	DIN	Annual	0.110	37.5	GOOD	0.077	19.6	GOOD
JMSMH	DIN	Spring1	0.179	29.0	GOOD	0.156	32.1	GOOD
JMSMH	DIN	Spring2	0.126	38.3	GOOD	0.133	28.4	GOOD
JMSMH	DIN	Summer1	0.074	64.6	POOR	0.067	17.9	GOOD
JMSMH	DIN	Summer2	0.054	43.2	FAIR	0.063	18.8	GOOD
JMSMH	TP	Annual	0.055	67.8	POOR	0.067	72.3	POOR
JMSMH	TP	Spring1	0.056	79.9	POOR	0.072	78.1	POOR
JMSMH	TP	Spring2	0.055	72.7	POOR	0.073	79.2	POOR
JMSMH	TP	Summer1	0.063	57.8	FAIR	0.083	77.0	POOR
JMSMH	TP	Summer2	0.070	61.8	POOR	0.089	75.2	POOR
JMSMH	DIP	Annual	0.020	92.3	POOR	0.019	84.0	POOR
JMSMH	DIP	Spring1	0.019	96.2	POOR	0.016	95.8	POOR
JMSMH	DIP	Spring2	0.020	95.4	POOR	0.018	92.8	POOR
JMSMH	DIP	Summer1	0.024	92.3	POOR	0.029	80.0	POOR
JMSMH	DIP	Summer2	0.034	92.1	POOR	0.032	78.2	POOR
JMSMH	CHLA	Annual	6.673	22.7	GOOD	-	-	-
JMSMH	CHLA	Spring1	4.540	17.9	GOOD	-	-	-
JMSMH	CHLA	Spring2	4.540	12.5	GOOD	-	-	-
JMSMH	CHLA	Summer1	7.138	22.4	GOOD	-	-	-
JMSMH	CHLA	Summer2	7.005	20.9	GOOD	-	-	-
JMSMH	TSS	Annual	13.000	66.1	POOR	29.250	78.2	POOR
JMSMH	TSS	Spring1	19.000	86.3	POOR	51.500	86.0	POOR
JMSMH	TSS	Spring2	17.500	77.4	POOR	51.500	91.7	POOR
JMSMH	TSS	Summer1	12.500	61.1	POOR	36.750	85.2	POOR
JMSMH	TSS	Summer2	13.000	58.8	POOR	42.500	84.7	POOR
JMSMH	SECCHI	Annual	0.925	25.9	POOR	-	-	-
JMSMH	SECCHI	Spring1	0.700	11.0	POOR	-	-	-
JMSMH	SECCHI	Spring2	0.750	19.8	POOR	-	-	-
JMSMH	SECCHI	Summer1	0.925	35.4	POOR	-	-	-
JMSMH	SECCHI	Summer2	0.900	36.2	POOR	-	-	-
JMSMH	DO	Spring1	-	-	-	8.030	-	GOOD
JMSMH	DO	Spring2	-	-	-	6.895	-	GOOD
JMSMH	DO	Summer1	-	-	-	6.338	-	GOOD
JMSMH	DO	Summer2	-	-	-	6.460	-	GOOD

Table 4-7. Water quality trends in segment JMSMH (only significant trends are displayed).

Segment	Parameter	Season	Layer	Baseline	Slope	%Change	%BDL	pValue	Direction
JMSMH	TN*	Annual	S	0.551	0.0100	31.14	0.00	0.0211	DEGRADING
JMSMH	TN*	Spring1	S	0.583	0.0180	51.93	0.00	0.0130	DEGRADING
JMSMH	TN*	Spring2	S	0.468	0.0270	99.18	0.00	0.0026	DEGRADING
JMSMH	TN*	Annual	B	0.536	0.0160	49.17	0.00	0.0043	DEGRADING
JMSMH	TN*	Spring1	B	0.563	0.0290	87.63	0.00	0.0039	DEGRADING
JMSMH	TN*	Spring2	B	0.474	0.0290	102.51	0.00	0.0011	DEGRADING
JMSMH	TP*	Annual	S	0.054	0.0030	94.44	0.00	<0.0001	DEGRADING
JMSMH	TP*	Spring1	S	0.048	0.0050	186.01	0.00	<0.0001	DEGRADING
JMSMH	TP*	Summer1	S	0.051	0.0030	107.07	0.00	0.0010	DEGRADING
JMSMH	TP*	Spring2	S	0.047	0.0040	150.68	0.00	0.0001	DEGRADING
JMSMH	TP*	Summer2	S	0.053	0.0030	90.41	0.00	0.0102	DEGRADING
JMSMH	TP*	Annual	B	0.059	0.0030	81.18	0.00	<0.0001	DEGRADING
JMSMH	TP*	Spring1	B	0.053	0.0060	180.50	0.00	0.0019	DEGRADING
JMSMH	TP*	Summer1	B	0.057	0.0040	125.87	0.00	0.0001	DEGRADING
JMSMH	TP*	Spring2	B	0.053	0.0040	135.61	0.00	0.0008	DEGRADING
JMSMH	TP*	Summer2	B	0.058	0.0040	102.90	0.00	0.0028	DEGRADING
JMSMH	PO4F*	Annual	S	0.018	0.0010	95.72	14.56	0.0015	DEGRADING
JMSMH	PO4F*	Summer1	S	0.021	0.0020	158.36	0.00	0.0058	DEGRADING
JMSMH	PO4F*	Spring2	S	0.012	0.0020	215.06	7.41	0.0280	DEGRADING
JMSMH	PO4F*	Summer2	S	0.025	0.0020	122.06	0.00	0.0492	DEGRADING
JMSMH	PO4F*	Annual	B	0.016	0.0010	72.67	16.50	0.0005	DEGRADING
JMSMH	PO4F*	Summer1	B	0.022	0.0020	141.74	0.00	0.0135	DEGRADING
JMSMH	PO4F*	Fall	B	0.023	0.0020	117.09	0.00	0.0235	DEGRADING
JMSMH	PO4F*	Spring2	B	0.009	0.0020	339.45	11.11	0.0052	DEGRADING
JMSMH	CHLA*	Summer2	S	4.00	0.173	73.31	0.08	0.0340	DEGRADING
JMSMH	TSS	Annual	B	142.00	0.938	11.22	0.00	0.0010	DEGRADING
JMSMH	TSS	Summer1	B	24.30	1.134	79.33	0.00	0.0070	DEGRADING
JMSMH	TSS	Summer2	B	19.90	1.100	93.97	0.00	0.0160	DEGRADING
JMSMH	DO	Spring1	B	8.70	-0.07	-13.03	0.00	0.0010	DEGRADING
JMSMH	WTEMP	Spring1	B	14.45	0.10	11.76	0.00	0.0160	INCREASING
JMSMH	WTEMP	Spring2	B	19.86	0.09	7.77	0.00	0.0210	INCREASING
JMSMH	PLL05	Annual	S	0.20	0.002	19.55	0.00	0.0280	IMPROVING

Table 4-8. SAV season water quality status in segment JMSMH (value is the median concentration; secchi depth in meters, chlorophyll *a* in µg/l, all other parameters in mg/l).

Segment	Parameter	Value	Score	Status	SAV Goal Value	Habitat Requirement
JMSMH	TN	0.478	9.8	Good	-	-
JMSMH	DIN	0.119	55.7	Fair	0.1340	Borderline
JMSMH	TP	0.067	68.4	Poor	-	-
JMSMH	DIP	0.022	93.2	Poor	0.0245	Fails
JMSMH	CHLA	5.18	11.4	Good	4.9	Pass
JMSMH	TSS	13.50	71.1	Poor	14.0	Borderline
JMSMH	SECCHI	0.85	22.7	Poor	-	-
JMSMH	KD	-	-	-	1.80	Fails
JMSMH	PLL05	-	-	-	0.136	Borderline
JMSMH	PLL10	-	-	-	0.060	Fails

Table 4-9. SAV Season Water quality trends in segment JMSMH (only significant trends are displayed).

Segment	Parameter	Season	Layer	Baseline	Slope	%Change	%BDL	pValue	Direction
JMSMH	TN*	SAV1	S	0.490	0.0120	42.70	0.00	0.0082	DEGRADING
JMSMH	TP*	SAV1	S	0.050	0.0040	142.11	0.00	<0.0001	DEGRADING
JMSMH	TP*	SAV2	S	0.057	0.0040	104.81	0.00	<0.0001	DEGRADING
JMSMH	PO4F*	SAV1	S	0.021	0.0010	115.38	3.17	0.0043	DEGRADING

Table 4-10. Water quality status in segment JMSOH (value is the median concentration, secchi depth in meters, chlorophyll *a* in µg/l, all other parameters in mg/l).

Segment	Parameter	Season	SValue	SScore	SStatus	BValue	BScore	BStatus
JMSOH	TN	Annual	0.652	6.9	GOOD	0.782	7.8	GOOD
JMSOH	TN	Spring1	0.659	4.9	GOOD	0.860	7.0	GOOD
JMSOH	TN	Spring2	0.573	4.0	GOOD	0.825	7.9	GOOD
JMSOH	TN	Summer1	0.506	3.8	GOOD	0.579	5.7	GOOD
JMSOH	TN	Summer2	0.498	3.9	GOOD	0.573	6.2	GOOD
JMSOH	DIN	Annual	0.188	19.5	GOOD	0.180	17.0	GOOD
JMSOH	DIN	Spring1	0.213	5.8	GOOD	0.209	5.3	GOOD
JMSOH	DIN	Spring2	0.186	12.7	GOOD	0.181	12.0	GOOD
JMSOH	DIN	Summer1	0.080	20.4	GOOD	0.108	24.3	GOOD
JMSOH	DIN	Summer2	0.067	14.6	GOOD	0.074	21.2	GOOD
JMSOH	TP	Annual	0.080	35.5	GOOD	0.109	41.5	FAIR
JMSOH	TP	Spring1	0.080	35.3	GOOD	0.143	54.2	FAIR
JMSOH	TP	Spring2	0.081	30.4	GOOD	0.160	52.2	FAIR
JMSOH	TP	Summer1	0.083	28.8	GOOD	0.108	35.4	GOOD
JMSOH	TP	Summer2	0.085	32.0	GOOD	0.107	36.3	GOOD
JMSOH	DIP	Annual	0.021	73.2	POOR	0.021	74.7	POOR
JMSOH	DIP	Spring1	0.015	60.6	POOR	0.016	61.2	POOR
JMSOH	DIP	Spring2	0.019	68.8	POOR	0.020	70.8	POOR
JMSOH	DIP	Summer1	0.028	80.3	POOR	0.030	78.0	POOR
JMSOH	DIP	Summer2	0.029	81.0	POOR	0.031	78.6	POOR
JMSOH	CHLA	Annual	8.778	42.2	GOOD	-	-	-
JMSOH	CHLA	Spring1	17.750	59.2	POOR	-	-	-
JMSOH	CHLA	Spring2	7.865	39.8	GOOD	-	-	-
JMSOH	CHLA	Summer1	9.623	28.3	GOOD	-	-	-
JMSOH	CHLA	Summer2	10.305	30.1	GOOD	-	-	-
JMSOH	TSS	Annual	26.000	52.6	FAIR	60.750	71.0	POOR
JMSOH	TSS	Spring1	41.000	70.8	POOR	102.500	83.8	POOR
JMSOH	TSS	Spring2	31.500	56.9	FAIR	104.000	83.0	POOR
JMSOH	TSS	Summer1	24.500	49.1	FAIR	53.750	62.9	POOR
JMSOH	TSS	Summer2	21.250	46.3	FAIR	51.500	63.3	POOR
JMSOH	SECCHI	Annual	0.525	63.4	GOOD	-	-	-
JMSOH	SECCHI	Spring1	0.400	63.9	GOOD	-	-	-
JMSOH	SECCHI	Spring2	0.400	59.1	GOOD	-	-	-
JMSOH	SECCHI	Summer1	0.575	58.8	FAIR	-	-	-
JMSOH	SECCHI	Summer2	0.600	54.0	FAIR	-	-	-
JMSOH	DO	Spring1	-	-	-	9.100	-	GOOD
JMSOH	DO	Spring2	-	-	-	7.070	-	GOOD
JMSOH	DO	Summer1	-	-	-	6.681	-	GOOD
JMSOH	DO	Summer2	-	-	-	6.710	-	GOOD

Table 4-11. Water quality trends in segment JMSOH (only significant trends are displayed).

Segment	Parameter	Season	Layer	Baseline	Slope	%Change	%BDL	pValue	Direction
JMSOH	TN*	Annual	B	0.822	0.0150	31.04	0.00	0.0406	DEGRADING
JMSOH	TN*	Spring1	B	0.857	0.0290	57.71	0.00	0.0302	DEGRADING
JMSOH	DIN*	Annual	S	0.424	-0.0170	-67.40	7.69	0.0004	IMPROVING
JMSOH	DIN*	Summer1	S	0.243	-0.0130	-92.96	19.44	0.0148	IMPROVING
JMSOH	DIN*	Annual	B	0.412	-0.0190	-79.63	4.81	0.0004	IMPROVING
JMSOH	DIN*	Summer1	B	0.246	-0.0140	-99.71	11.11	0.0131	IMPROVING
JMSOH	DIN*	Fall	B	0.485	-0.0290	-101.65	3.70	0.0250	IMPROVING
JMSOH	DIN*	Summer2	B	0.200	-0.0140	-117.30	14.81	0.0233	IMPROVING
JMSOH	TP*	Annual	S	0.065	0.0040	102.59	0.00	<0.0001	DEGRADING
JMSOH	TP*	Spring1	S	0.062	0.0070	196.66	0.00	0.0013	DEGRADING
JMSOH	TP*	Summer1	S	0.051	0.0050	152.70	0.00	0.0019	DEGRADING
JMSOH	TP*	Spring2	S	0.057	0.0060	166.65	0.00	0.0076	DEGRADING
JMSOH	TP*	Summer2	S	0.049	0.0040	147.06	0.00	0.0153	DEGRADING
JMSOH	TP*	Annual	B	0.082	0.0090	189.12	0.00	<0.0001	DEGRADING
JMSOH	TP*	Spring1	B	0.080	0.0170	353.48	0.00	<0.0001	DEGRADING
JMSOH	TP*	Summer1	B	0.075	0.0060	140.59	0.00	0.0041	DEGRADING
JMSOH	TP*	Spring2	B	0.075	0.0120	265.89	0.00	0.0037	DEGRADING
JMSOH	TP*	Summer2	B	0.074	0.0070	160.94	0.00	0.0067	DEGRADING
JMSOH	PO4F*	Summer1	S	0.018	0.0010	124.78	0.00	0.0276	DEGRADING
JMSOH	PO4F*	Winter	S	0.043	-0.0030	-115.61	0.00	0.0317	IMPROVING
JMSOH	PO4F*	Summer2	S	0.019	0.0010	114.37	0.00	0.0350	DEGRADING
JMSOH	TSS	Annual	S	662.00	-0.613	-1.57	0.01	0.0270	IMPROVING
JMSOH	DO	Spring1	B	9.10	-0.05	-9.34	0.00	0.0450	DEGRADING
JMSOH	SALIN	Annual	S	2.84	0.05	29.89	0.00	0.0080	INCREASING
JMSOH	SALIN	Annual	B	3.76	0.08	38.30	0.00	0.0030	INCREASING
JMSOH	WTEMP	Spring1	B	15.89	0.11	11.23	0.00	0.0430	INCREASING
JMSOH	WTEMP	Spring2	B	21.03	0.10	8.45	0.00	0.0460	INCREASING
JMSOH	PLL05	Annual	S	0.00	0.003	0.00	0.00	0.0010	IMPROVING
JMSOH	PLL10	Annual	S	0.00	0.001	0.00	0.00	0.0020	IMPROVING

Table 4-12. SAV season water quality status in segment JMSOH (value is the median concentration; secchi depth in meters, chlorophyll *a* in µg/l, all other parameters in mg/l).

Segment	Parameter	Value	Score	Status	SAV Goal Value	Habitat Requirement
JMSOH	TN	0.534	5.0	Good	-	-
JMSOH	DIN	0.124	21.6	Good	0.1325	-
JMSOH	TP	0.081	32.1	Good	-	-
JMSOH	DIP	0.026	79.5	Poor	0.0265	Fails
JMSOH	CHLA	7.93	31.3	Good	8.8	Pass
JMSOH	TSS	25.25	54.4	Fair	25.5	Fails
JMSOH	SECCHI	0.55	63.4	Good	-	-
JMSOH	KD	-	-	-	2.90	Fails
JMSOH	PLL05	-	-	-	0.062	Fails
JMSOH	PLL10	-	-	-	0.016	Fails

Table 4-13. SAV Season Water quality trends in segment JMSOH (only significant trends are displayed).

Segment	Parameter	Season	Layer	Baseline	Slope	%Change	%BDL	pValue	Direction
JMSOH	DIN*	SAV1	S	0.289	-0.0140	-79.90	12.70	0.0078	IMPROVING
JMSOH	DIN*	SAV2	S	0.414	-0.0250	-103.45	7.41	0.0040	IMPROVING
JMSOH	TP*	SAV1	S	0.051	0.0040	129.52	0.00	0.0001	DEGRADING
JMSOH	TP*	SAV2	S	0.064	0.0040	111.28	0.00	0.0002	DEGRADING
JMSOH	PO4F*	SAV1	S	0.017	0.0010	88.69	3.17	0.0084	DEGRADING
JMSOH	PLL05	SAV1	S	0.00	0.002	0.00	0.00	0.0390	IMPROVING

Table 4-14. Water quality status in segment JMSTF (value is the median concentration, secchi depth in meters, chlorophyll *a* in µg/l, all other parameters in mg/l).

Segment	Parameter	Season	SValue	SScore	SStatus	BValue	BScore	BStatus
JMSTF	TN	Annual	0.760	9.8	GOOD	0.865	10.6	GOOD
JMSTF	TN	Spring1	0.674	9.5	GOOD	0.865	11.2	GOOD
JMSTF	TN	Spring2	0.749	10.7	GOOD	0.879	11.7	GOOD
JMSTF	TN	Summer1	0.863	14.9	GOOD	1.026	15.5	GOOD
JMSTF	TN	Summer2	0.895	15.1	GOOD	1.065	15.7	GOOD
JMSTF	DIN	Annual	0.342	19.2	GOOD	0.378	19.9	GOOD
JMSTF	DIN	Spring1	0.379	12.2	GOOD	0.378	10.9	GOOD
JMSTF	DIN	Spring2	0.295	12.6	GOOD	0.349	11.1	GOOD
JMSTF	DIN	Summer1	0.167	15.7	GOOD	0.238	25.9	GOOD
JMSTF	DIN	Summer2	0.148	19.9	GOOD	0.213	30.6	GOOD
JMSTF	TP	Annual	0.083	42.0	FAIR	0.099	49.8	FAIR
JMSTF	TP	Spring1	0.079	43.7	FAIR	0.098	54.2	FAIR
JMSTF	TP	Spring2	0.081	38.5	GOOD	0.105	52.2	FAIR
JMSTF	TP	Summer1	0.085	35.1	GOOD	0.117	46.5	FAIR
JMSTF	TP	Summer2	0.085	33.4	GOOD	0.122	48.0	FAIR
JMSTF	DIP	Annual	0.022	47.1	FAIR	0.020	54.2	FAIR
JMSTF	DIP	Spring1	0.020	45.3	FAIR	0.018	53.6	FAIR
JMSTF	DIP	Spring2	0.023	42.3	GOOD	0.018	49.2	FAIR
JMSTF	DIP	Summer1	0.027	49.9	FAIR	0.024	58.1	FAIR
JMSTF	DIP	Summer2	0.026	49.8	FAIR	0.024	60.6	POOR
JMSTF	CHLA	Annual	9.390	61.1	POOR	-	-	-
JMSTF	CHLA	Spring1	8.570	61.7	POOR	-	-	-
JMSTF	CHLA	Spring2	12.400	72.6	POOR	-	-	-
JMSTF	CHLA	Summer1	17.873	57.8	POOR	-	-	-
JMSTF	CHLA	Summer2	19.715	54.3	FAIR	-	-	-
JMSTF	TSS	Annual	14.500	58.1	FAIR	36.000	55.9	FAIR
JMSTF	TSS	Spring1	22.500	59.7	POOR	39.000	64.1	POOR
JMSTF	TSS	Spring2	16.000	57.3	POOR	26.000	47.7	FAIR
JMSTF	TSS	Summer1	14.500	40.8	GOOD	36.000	40.4	GOOD
JMSTF	TSS	Summer2	14.250	44.1	FAIR	51.000	57.9	POOR
JMSTF	SECCHI	Annual	0.500	44.1	FAIR	-	-	-
JMSTF	SECCHI	Spring1	0.500	43.4	FAIR	-	-	-
JMSTF	SECCHI	Spring2	0.500	43.3	FAIR	-	-	-
JMSTF	SECCHI	Summer1	0.500	58.8	FAIR	-	-	-
JMSTF	SECCHI	Summer2	0.600	58.0	FAIR	-	-	-
JMSTF	DO	Spring1	-	-	-	9.220	-	GOOD
JMSTF	DO	Spring2	-	-	-	8.210	-	GOOD
JMSTF	DO	Summer1	-	-	-	7.295	-	GOOD
JMSTF	DO	Summer2	-	-	-	7.290	-	GOOD

Table 4-15. Water quality trends in segment JMSTF (only significant trends are displayed).

Segment	Parameter	Season	Layer	Baseline	Slope	%Change	%BDL	pValue	Direction
JMSTF	TN*	Annual	S	1.054	-0.0390	-63.07	0.00	<0.0001	IMPROVING
JMSTF	TN*	Summer1	S	1.144	-0.0550	-81.01	0.00	0.0006	IMPROVING
JMSTF	TN*	Winter	S	1.032	-0.0470	-78.07	0.00	0.0449	IMPROVING
JMSTF	TN*	Spring2	S	0.976	-0.0370	-63.90	0.00	0.0017	IMPROVING
JMSTF	TN*	Summer2	S	1.135	-0.0520	-77.70	0.00	0.0039	IMPROVING
JMSTF	TN*	Annual	B	1.277	-0.0290	-39.02	0.00	0.0051	IMPROVING
JMSTF	TN*	Summer1	B	1.404	-0.0510	-61.26	0.00	0.0122	IMPROVING
JMSTF	TN*	Spring2	B	1.094	-0.0400	-62.45	0.00	0.0052	IMPROVING
JMSTF	TN*	Summer2	B	1.439	-0.0500	-59.06	0.00	0.0407	IMPROVING
JMSTF	DIN*	Annual	S	0.681	-0.0310	-78.18	0.00	<0.0001	IMPROVING
JMSTF	DIN*	Summer1	S	0.652	-0.0390	-102.40	0.00	0.0004	IMPROVING
JMSTF	DIN*	Fall	S	0.900	-0.0370	-68.93	0.00	0.0466	IMPROVING
JMSTF	DIN*	Spring2	S	0.593	-0.0300	-86.06	0.00	0.0039	IMPROVING
JMSTF	DIN*	Summer2	S	0.652	-0.0370	-97.55	0.00	0.0115	IMPROVING
JMSTF	DIN*	Annual	B	0.824	-0.0400	-82.55	0.00	<0.0001	IMPROVING
JMSTF	DIN*	Spring1	B	0.636	-0.0260	-69.20	0.00	0.0492	IMPROVING
JMSTF	DIN*	Summer1	B	0.797	-0.0440	-93.26	0.00	<0.0001	IMPROVING
JMSTF	DIN*	Fall	B	1.120	-0.0480	-72.11	0.00	0.0219	IMPROVING
JMSTF	DIN*	Spring2	B	0.680	-0.0360	-89.69	0.00	0.0010	IMPROVING
JMSTF	DIN*	Summer2	B	0.795	-0.0420	-89.56	0.00	0.0003	IMPROVING
JMSTF	TP*	Annual	S	0.118	-0.0040	-57.50	0.00	0.0020	IMPROVING
JMSTF	TP*	Summer1	S	0.130	-0.0040	-48.46	0.00	0.0401	IMPROVING
JMSTF	TP*	Spring2	S	0.101	-0.0050	-75.95	0.00	0.0064	IMPROVING
JMSTF	TP*	Annual	B	0.133	-0.0030	-34.40	0.00	0.0235	IMPROVING
JMSTF	TP*	Spring2	B	0.130	-0.0040	-52.33	0.00	0.0047	IMPROVING
JMSTF	PO4F*	Annual	S	0.115	-0.0080	-118.31	0.95	<0.0001	IMPROVING
JMSTF	PO4F*	Spring1	S	0.089	-0.0090	-165.51	3.70	0.0001	IMPROVING
JMSTF	PO4F*	Summer1	S	0.128	-0.0070	-91.80	0.00	0.0007	IMPROVING
JMSTF	PO4F*	Fall	S	0.126	-0.0070	-93.19	0.00	0.0206	IMPROVING
JMSTF	PO4F*	Winter	S	0.128	-0.0130	-169.59	0.00	0.0160	IMPROVING
JMSTF	PO4F*	Spring2	S	0.091	-0.0070	-128.90	0.00	0.0018	IMPROVING
JMSTF	PO4F*	Summer2	S	0.136	-0.0090	-114.89	0.00	0.0012	IMPROVING
JMSTF	PO4F*	Annual	B	0.109	-0.0050	-71.63	0.96	<0.0001	IMPROVING
JMSTF	PO4F*	Spring1	B	0.087	-0.0070	-134.43	3.85	0.0007	IMPROVING
JMSTF	PO4F*	Fall	B	0.133	-0.0050	-62.59	0.00	0.0195	IMPROVING
JMSTF	PO4F*	Winter	B	0.127	-0.0100	-131.40	0.00	0.0411	IMPROVING
JMSTF	PO4F*	Spring2	B	0.092	-0.0050	-84.86	0.00	0.0222	IMPROVING
JMSTF	CHLA*	Annual	S	12.60	0.173	23.33	0.10	0.0020	DEGRADING
JMSTF	TSS	Annual	B	172.00	1.000	9.88	0.00	0.0200	DEGRADING
JMSTF	TSS	Summer1	B	34.00	2.000	100.00	0.00	0.0130	DEGRADING
JMSTF	TSS	Summer2	B	27.50	3.000	185.45	0.00	0.0050	DEGRADING
JMSTF	SECCHI	Spring2	S	0.70	-0.01	-16.27	0.00	0.0380	DEGRADING
JMSTF	DO	Summer1	B	6.40	0.06	15.70	0.00	<0.0001	IMPROVING
JMSTF	WTEMP	Spring2	S	22.18	0.12	9.38	0.00	0.0100	INCREASING
JMSTF	WTEMP	Spring1	B	16.92	0.14	14.05	0.00	0.0260	INCREASING
JMSTF	WTEMP	Spring2	B	21.71	0.15	11.75	0.00	0.0070	INCREASING

Table 4-16. SAV season water quality status in segment JMSTF (value is the median concentration; secchi depth in meters, chlorophyll *a* in µg/l, all other parameters in mg/l).

Segment	Parameter	Value	Score	Status	SAV Goal Value	Habitat Requirement
JMSTF	TN	0.810	12.0	Good	-	-
JMSTF	DIN	0.236	17.1	Good	0.2660	-
JMSTF	TP	0.082	36.6	Good	-	-
JMSTF	DIP	0.025	49.2	Fair	0.0220	Borderline
JMSTF	CHLA	16.03	66.6	Poor	15.4	Borderline
JMSTF	TSS	14.50	47.0	Fair	15.0	Borderline
JMSTF	SECCHI	0.50	50.2	Fair	-	-
JMSTF	KD	-	-	-	2.90	Fails
JMSTF	PLL05	-	-	-	0.073	Borderline
JMSTF	PLL10	-	-	-	0.018	Fails

Table 4-17. SAV Season Water quality trends in segment JMSTF (only significant trends are displayed).

Segment	Parameter	Season	Layer	Baseline	Slope	%Change	%BDL	pValue	Direction
JMSTF	TN*	SAV1	S	1.110	-0.0440	-67.25	0.00	<0.0001	IMPROVING
JMSTF	TN*	SAV2	S	1.005	-0.0290	-48.19	0.00	0.0269	IMPROVING
JMSTF	DIN*	SAV1	S	0.680	-0.0340	-85.24	0.00	<0.0001	IMPROVING
JMSTF	DIN*	SAV2	S	0.687	-0.0200	-48.74	0.00	0.0152	IMPROVING
JMSTF	TP*	SAV1	S	0.122	-0.0040	-55.89	0.00	0.0013	IMPROVING
JMSTF	TP*	SAV2	S	0.113	-0.0040	-60.22	0.00	0.0154	IMPROVING
JMSTF	PO4F*	SAV1	S	0.119	-0.0070	-98.91	0.00	<0.0001	IMPROVING
JMSTF	PO4F*	SAV2	S	0.115	-0.0080	-115.19	1.85	<0.0001	IMPROVING

Table 4-18. Water quality status in segment APPTF (value is the median concentration, secchi depth in meters, chlorophyll *a* in µg/l, all other parameters in mg/l).

Segment	Parameter	Season	SValue	SScore	SStatus	BValue	BScore	BStatus
APPTF	TN	Annual	0.840	13.5	GOOD	0.854	10.1	GOOD
APPTF	TN	Spring1	0.737	10.4	GOOD	0.842	11.4	GOOD
APPTF	TN	Spring2	0.861	15.6	GOOD	0.850	11.0	GOOD
APPTF	TN	Summer1	0.939	17.1	GOOD	0.949	13.5	GOOD
APPTF	TN	Summer2	0.920	15.7	GOOD	0.982	15.2	GOOD
APPTF	DIN	Annual	0.270	13.1	GOOD	0.273	11.3	GOOD
APPTF	DIN	Spring1	0.223	4.9	GOOD	0.205	3.1	GOOD
APPTF	DIN	Spring2	0.191	4.5	GOOD	0.173	2.3	GOOD
APPTF	DIN	Summer1	0.203	14.1	GOOD	0.160	9.5	GOOD
APPTF	DIN	Summer2	0.138	10.2	GOOD	0.075	3.9	GOOD
APPTF	TP	Annual	0.092	49.9	FAIR	0.101	46.7	FAIR
APPTF	TP	Spring1	0.073	38.3	GOOD	0.076	32.3	GOOD
APPTF	TP	Spring2	0.093	51.0	FAIR	0.106	50.6	FAIR
APPTF	TP	Summer1	0.110	54.6	FAIR	0.129	57.7	FAIR
APPTF	TP	Summer2	0.100	43.8	FAIR	0.133	58.5	FAIR
APPTF	DIP	Annual	0.014	30.7	GOOD	0.012	30.6	GOOD
APPTF	DIP	Spring1	0.012	25.4	GOOD	0.011	27.7	GOOD
APPTF	DIP	Spring2	0.011	20.8	GOOD	0.011	25.3	GOOD
APPTF	DIP	Summer1	0.015	32.9	GOOD	0.014	36.3	GOOD
APPTF	DIP	Summer2	0.014	30.9	GOOD	0.014	38.6	GOOD
APPTF	CHLA	Annual	21.570	85.1	POOR	-	-	-
APPTF	CHLA	Spring1	6.370	53.1	FAIR	-	-	-
APPTF	CHLA	Spring2	21.560	85.7	POOR	-	-	-
APPTF	CHLA	Summer1	41.135	87.4	POOR	-	-	-
APPTF	CHLA	Summer2	41.630	86.0	POOR	-	-	-
APPTF	TSS	Annual	23.000	72.8	POOR	28.000	50.1	FAIR
APPTF	TSS	Spring1	20.000	62.9	POOR	26.000	44.8	FAIR
APPTF	TSS	Spring2	25.000	71.6	POOR	41.500	67.3	POOR
APPTF	TSS	Summer1	30.000	85.0	POOR	38.000	63.6	POOR
APPTF	TSS	Summer2	28.500	82.6	POOR	35.500	59.6	POOR
APPTF	SECCHI	Annual	0.500	44.1	FAIR	-	-	-
APPTF	SECCHI	Spring1	0.450	34.5	POOR	-	-	-
APPTF	SECCHI	Spring2	0.500	43.3	FAIR	-	-	-
APPTF	SECCHI	Summer1	0.400	22.0	POOR	-	-	-
APPTF	SECCHI	Summer2	0.400	21.9	POOR	-	-	-
APPTF	DO	Spring1	-	-	-	9.200	-	GOOD
APPTF	DO	Spring2	-	-	-	8.250	-	GOOD
APPTF	DO	Summer1	-	-	-	8.655	-	GOOD
APPTF	DO	Summer2	-	-	-	8.710	-	GOOD

Table 4-19. Water quality trends in segment APPTF (only significant trends are displayed).

Segment	Parameter	Season	Layer	Baseline	Slope	% Change	% BDL	pValue	Direction
APPTF	TP*	Annual	B	0.098	0.0020	34.56	0.96	0.0320	DEGRADING
APPTF	TP*	Summer2	B	0.106	0.0040	64.04	0.00	0.0320	DEGRADING
APPTF	PO4F*	Annual	S	0.042	-0.0020	-84.22	25.00	0.0007	IMPROVING
APPTF	PO4F*	Annual	B	0.039	-0.0030	-138.49	26.92	0.0001	IMPROVING
APPTF	PO4F*	Spring1	B	0.036	-0.0050	-220.19	23.08	0.0238	IMPROVING
APPTF	PO4F*	Summer1	B	0.026	-0.0020	-141.94	22.22	0.0287	IMPROVING
APPTF	DO	Summer1	B	8.20	0.06	11.84	0.00	0.0240	IMPROVING
APPTF	WTEMP	Annual	S	19.68	0.09	7.78	0.00	0.0070	INCREASING
APPTF	WTEMP	Summer1	S	25.63	0.12	8.21	0.00	0.0410	INCREASING
APPTF	WTEMP	Annual	B	19.00	0.10	8.82	0.00	0.0090	INCREASING
APPTF	PLL05	Spring2	S	0.00	0.002	0.00	0.00	0.0360	IMPROVING

Table 4-20. SAV season water quality status in segment APPTF (value is the median concentration; secchi depth in meters, chlorophyll *a* in µg/l, all other parameters in mg/l).

Segment	Parameter	Value	Score	Status	SAV Goal Value	Habitat Requirement
APPTF	TN	0.934	18.7	Good	-	-
APPTF	DIN	0.203	11.3	Good	0.2030	-
APPTF	TP	0.098	50.4	Fair	-	-
APPTF	DIP	0.010	19.5	Good	0.0100	Pass
APPTF	CHLA	40.05	90.3	Poor	40.1	Fails
APPTF	TSS	28.00	80.8	Poor	28.0	Fails
APPTF	SECCHI	0.50	41.5	Fair	-	-
APPTF	KD	-	-	-	2.90	Fails
APPTF	PLL05	-	-	-	0.032	Fails
APPTF	PLL10	-	-	-	0.009	Fails

Table 4-21. SAV Season Water quality trends in segment APPTF (only significant trends are displayed).

Segment	Parameter	Season	Layer	Baseline	Slope	%Change	%BDL	pValue	Direction
APPTF	TN*	SAV1	S	1.121	-0.0270	-41.10	0.00	0.0435	IMPROVING
APPTF	PO4F*	SAV2	S	0.039	-0.0020	-95.00	28.30	0.0112	IMPROVING

Table 4-22. Water quality status in segment CHKOH (value is the median concentration, secchi depth in meters, chlorophyll *a* in µg/l, all other parameters in mg/l).

Segment	Parameter	Season	SValue	SScore	SStatus	BValue	BScore	BStatus
CHKOH	TN	Annual	0.647	6.6	GOOD	0.715	7.9	GOOD
CHKOH	TN	Spring1	0.667	4.7	GOOD	0.714	4.3	GOOD
CHKOH	TN	Spring2	0.657	6.1	GOOD	0.714	6.4	GOOD
CHKOH	TN	Summer1	0.636	9.8	GOOD	0.728	12.7	GOOD
CHKOH	TN	Summer2	0.622	10.0	GOOD	0.764	16.4	GOOD
CHKOH	DIN	Annual	0.056	4.4	GOOD	0.064	4.6	GOOD
CHKOH	DIN	Spring1	0.052	0.5	GOOD	0.042	0.3	GOOD
CHKOH	DIN	Spring2	0.051	1.8	GOOD	0.049	1.5	GOOD
CHKOH	DIN	Summer1	0.016	2.7	GOOD	0.015	2.0	GOOD
CHKOH	DIN	Summer2	0.016	3.4	GOOD	0.011	1.8	GOOD
CHKOH	TP	Annual	0.079	38.1	FAIR	0.097	37.1	GOOD
CHKOH	TP	Spring1	0.082	37.7	GOOD	0.093	30.3	GOOD
CHKOH	TP	Spring2	0.086	36.8	GOOD	0.090	24.1	GOOD
CHKOH	TP	Summer1	0.074	27.6	GOOD	0.132	50.0	FAIR
CHKOH	TP	Summer2	0.075	29.1	GOOD	0.157	63.3	POOR
CHKOH	DIP	Annual	0.010	41.6	FAIR	0.010	41.3	FAIR
CHKOH	DIP	Spring1	0.008	36.5	GOOD	0.007	31.0	GOOD
CHKOH	DIP	Spring2	0.010	41.3	FAIR	0.009	36.5	GOOD
CHKOH	DIP	Summer1	0.011	42.7	FAIR	0.012	41.6	FAIR
CHKOH	DIP	Summer2	0.012	48.0	FAIR	0.012	43.5	FAIR
CHKOH	CHLA	Annual	16.750	67.0	POOR	-	-	-
CHKOH	CHLA	Spring1	21.200	75.4	POOR	-	-	-
CHKOH	CHLA	Spring2	21.200	73.2	POOR	-	-	-
CHKOH	CHLA	Summer1	17.850	57.7	FAIR	-	-	-
CHKOH	CHLA	Summer2	17.690	53.5	FAIR	-	-	-
CHKOH	TSS	Annual	23.000	50.3	FAIR	38.000	52.9	FAIR
CHKOH	TSS	Spring1	23.000	37.3	GOOD	34.000	40.7	GOOD
CHKOH	TSS	Spring2	22.000	33.7	GOOD	29.000	29.7	GOOD
CHKOH	TSS	Summer1	21.000	44.4	FAIR	38.000	47.0	FAIR
CHKOH	TSS	Summer2	22.000	50.9	FAIR	49.500	60.1	POOR
CHKOH	SECCHI	Annual	0.500	63.4	GOOD	-	-	-
CHKOH	SECCHI	Spring1	0.400	63.9	GOOD	-	-	-
CHKOH	SECCHI	Spring2	0.450	69.2	GOOD	-	-	-
CHKOH	SECCHI	Summer1	0.500	58.8	FAIR	-	-	-
CHKOH	SECCHI	Summer2	0.500	54.0	FAIR	-	-	-
CHKOH	DO	Spring1	-	-	-	8.980	-	GOOD
CHKOH	DO	Spring2	-	-	-	7.510	-	GOOD
CHKOH	DO	Summer1	-	-	-	6.470	-	GOOD
CHKOH	DO	Summer2	-	-	-	6.340	-	GOOD

Table 4-23. Water quality trends in segment CHKOH (only significant trends are displayed).

Segment	Parameter	Season	Layer	Baseline	Slope	% Change	% BDL	pValue	Direction
CHKOH	TN*	Annual	S	0.889	-0.0270	-0.42	0.00	0.0332	IMPROVING
CHKOH	TN*	Spring1	S	0.812	-0.0520	-0.90	0.00	0.0195	IMPROVING
CHKOH	TN*	Spring2	S	0.733	-0.0480	-0.92	0.00	0.0067	IMPROVING
CHKOH	TP*	Annual	S	0.058	0.0020	0.48	0.00	0.0229	DEGRADING
CHKOH	TP*	Annual	B	0.072	0.0040	0.76	0.00	0.0272	DEGRADING
CHKOH	PO4F*	Spring2	B	0.018	-0.0020	-1.34	50.00	0.0090	IMPROVING
CHKOH	TSS	Annual	S	17.50	0.581	56.46	0.00	0.0040	DEGRADING
CHKOH	TSS	Summer2	S	17.30	0.750	73.70	0.00	0.0050	DEGRADING
CHKOH	TSS	Annual	B	27.00	1.417	89.20	0.00	<0.0001	DEGRADING
CHKOH	TSS	Summer1	B	35.30	2.000	96.32	0.00	0.0340	DEGRADING
CHKOH	TSS	Summer2	B	36.30	2.500	117.08	0.00	0.0080	DEGRADING
CHKOH	SECCHI	Summer2	S	0.70	-0.01	-24.29	0.00	0.0040	DEGRADING
CHKOH	SALIN	Summer2	S	0.00	0.02	0.00	0.00	0.0140	INCREASING
CHKOH	SALIN	Summer2	B	0.00	0.02	0.00	0.00	0.0140	INCREASING
CHKOH	WTEMP	Spring1	S	14.35	0.16	19.11	0.00	0.0390	INCREASING
CHKOH	WTEMP	Spring2	S	19.13	0.21	18.99	0.00	0.0100	INCREASING
CHKOH	WTEMP	Spring1	B	14.15	0.17	20.89	0.00	0.0260	INCREASING
CHKOH	WTEMP	Spring2	B	18.98	0.21	18.42	0.00	0.0040	INCREASING
CHKOH	PLL05	Annual	S	0.10	-0.003	-45.90	0.00	0.0020	DEGRADING
CHKOH	PLL05	Summer2	S	0.10	-0.004	-71.40	0.00	0.0170	DEGRADING
CHKOH	PLL10	Annual	S	0.00	-0.001	0.00	0.00	0.0020	DEGRADING
CHKOH	PLL10	Summer2	S	0.00	-0.002	0.00	0.00	0.0130	DEGRADING

Table 4-24. SAV Season Water quality trends in segment CHKOH (only significant trends are displayed).

Segment	Parameter	Season	Layer	Baseline	Slope	%Change	%BDL	pValue	Direction
CHKOH	TN*	SAV1	S	0.845	-0.0300	-0.50	0.00	0.0457	IMPROVING
CHKOH	TSS	SAV1	S	17.50	0.500	48.57	0.00	0.0080	DEGRADING
CHKOH	SECCHI	SAV1	S	0.60	-0.01	-15.87	0.00	0.0060	DEGRADING
CHKOH	PLL05	SAV1	S	0.10	-0.003	-52.70	0.00	0.0060	DEGRADING
CHKOH	PLL10	SAV1	S	0.00	-0.001	0.00	0.00	0.0080	DEGRADING

Table 4-25. SAV season water quality status in segment CHKOH (value is the median concentration; secchi depth in meters, chlorophyll *a* in µg/l, all other parameters in mg/l).

Segment	Parameter	Value	Score	Status	SAV Goal Value	Habitat Requirement
CHKOH	TN	0.632	8.1	Good	-	-
CHKOH	DIN	0.022	2.4	Good	0.0220	-
CHKOH	TP	0.075	30.2	Good	-	-
CHKOH	DIP	0.010	40.7	Fair	0.0100	Pass
CHKOH	CHLA	18.01	60.5	Poor	18.0	Fails
CHKOH	TSS	21.50	43.7	Fair	21.5	Fails
CHKOH	SECCHI	0.50	63.4	Good	-	-
CHKOH	KD	-	-	-	2.90	Fails
CHKOH	PLL05	-	-	-	0.069	Borderline
CHKOH	PLL10	-	-	-	0.016	Fails

Table 4-26. Water quality trends in segment ELIPH (only significant trends are displayed).

Segment	Parameter	Season	Layer	Baseline	Slope	%Change	%BDL	pValue	Direction
ELIPH	TN*	Annual	S	0.548	0.0150	45.57	0.00	0.0197	DEGRADING
ELIPH	TN*	Summer1	S	0.558	0.0250	75.31	0.00	0.0123	DEGRADING
ELIPH	TN*	Spring2	S	0.510	0.0190	62.63	0.00	0.0302	DEGRADING
ELIPH	TN*	Summer2	S	0.576	0.0250	72.93	0.00	0.0407	DEGRADING
ELIPH	TN*	Annual	B	0.549	0.0110	32.52	0.00	0.0282	DEGRADING
ELIPH	TN*	Spring2	B	0.480	0.0210	73.27	0.00	0.0300	DEGRADING
ELIPH	DIN*	Spring1	S	0.125	0.0150	198.27	0.00	0.0362	DEGRADING
ELIPH	DIN*	Spring2	S	0.136	0.0080	96.16	0.00	0.0088	DEGRADING
ELIPH	TP*	Annual	S	0.051	0.0010	20.19	0.97	0.0288	DEGRADING
ELIPH	TP*	Annual	B	0.055	0.0010	42.95	0.00	0.0150	DEGRADING
ELIPH	TP*	Spring1	B	0.041	0.0020	91.42	0.00	0.0306	DEGRADING
ELIPH	PO4F*	Fall	S	0.023	0.0010	88.09	0.00	0.0227	DEGRADING
ELIPH	PO4F*	Fall	B	0.021	0.0010	47.57	0.00	0.0284	DEGRADING
ELIPH	TSS	Annual	S	8.00	-0.333	-70.83	0.04	0.0120	IMPROVING
ELIPH	TSS	Summer1	S	16.00	-0.500	-53.13	0.00	0.0200	IMPROVING
ELIPH	TSS	Summer2	S	17.30	-0.732	-71.94	0.00	0.0040	IMPROVING
ELIPH	SECCHI	Annual	S	1.10	-0.01	-16.54	0.00	0.0010	DEGRADING
ELIPH	SECCHI	Summer1	S	1.10	-0.01	-18.55	0.00	0.0020	DEGRADING
ELIPH	SECCHI	Summer2	S	1.10	-0.01	-22.10	0.00	0.0020	DEGRADING
ELIPH	DO	Spring1	B	8.20	-0.05	-10.37	0.00	0.0240	DEGRADING
ELIPH	SALIN	Summer1	S	23.39	-0.21	-15.03	0.00	0.0020	DECREASING
ELIPH	SALIN	Summer2	B	25.38	-0.17	-11.13	0.00	0.0190	DECREASING
ELIPH	PLL05	Annual	S	0.10	0.004	68.00	0.00	0.0150	IMPROVING

Table 4-27. Water quality status in segment ELIPH (value is the median concentration, secchi depth in meters, chlorophyll *a* in µg/l, all other parameters in mg/l).

Segment	Parameter	Season	SValue	SScore	SStatus	BValue	BScore	BStatus
ELIPH	TN	Annual	0.535	68.9	POOR	0.517	66.9	POOR
ELIPH	TN	Spring1	0.555	73.7	POOR	0.548	76.0	POOR
ELIPH	TN	Spring2	0.529	69.3	POOR	0.571	81.1	POOR
ELIPH	TN	Summer1	0.554	70.3	POOR	0.570	71.7	POOR
ELIPH	TN	Summer2	0.580	72.6	POOR	0.569	68.0	POOR
ELIPH	DIN	Annual	0.121	84.0	POOR	0.106	77.3	POOR
ELIPH	DIN	Spring1	0.173	89.5	POOR	0.085	82.5	POOR
ELIPH	DIN	Spring2	0.163	92.0	POOR	0.119	89.2	POOR
ELIPH	DIN	Summer1	0.142	93.6	POOR	0.148	81.7	POOR
ELIPH	DIN	Summer2	0.181	94.9	POOR	0.153	78.9	POOR
ELIPH	TP	Annual	0.054	89.1	POOR	0.067	85.8	POOR
ELIPH	TP	Spring1	0.056	95.5	POOR	0.068	94.0	POOR
ELIPH	TP	Spring2	0.052	93.3	POOR	0.068	94.4	POOR
ELIPH	TP	Summer1	0.077	95.2	POOR	0.085	89.2	POOR
ELIPH	TP	Summer2	0.081	95.0	POOR	0.089	89.0	POOR
ELIPH	DIP	Annual	0.015	83.9	POOR	0.020	82.3	POOR
ELIPH	DIP	Spring1	0.013	91.3	POOR	0.012	87.2	POOR
ELIPH	DIP	Spring2	0.013	89.6	POOR	0.020	92.9	POOR
ELIPH	DIP	Summer1	0.032	91.1	POOR	0.042	88.9	POOR
ELIPH	DIP	Summer2	0.041	93.6	POOR	0.043	87.2	POOR
ELIPH	CHLA	Annual	9.410	68.9	POOR	-	-	-
ELIPH	CHLA	Spring1	8.630	54.2	FAIR	-	-	-
ELIPH	CHLA	Spring2	8.630	58.7	POOR	-	-	-
ELIPH	CHLA	Summer1	10.663	80.3	POOR	-	-	-
ELIPH	CHLA	Summer2	10.755	79.7	POOR	-	-	-
ELIPH	TSS	Annual	10.000	56.9	FAIR	24.000	71.5	POOR
ELIPH	TSS	Spring1	12.000	72.9	POOR	47.000	96.6	POOR
ELIPH	TSS	Spring2	13.000	80.6	POOR	33.000	92.8	POOR
ELIPH	TSS	Summer1	10.875	60.7	POOR	24.000	66.4	POOR
ELIPH	TSS	Summer2	10.000	51.2	FAIR	19.000	44.3	FAIR
ELIPH	SECCHI	Annual	0.900	5.5	POOR	-	-	-
ELIPH	SECCHI	Spring1	0.800	4.1	POOR	-	-	-
ELIPH	SECCHI	Spring2	0.900	5.0	POOR	-	-	-
ELIPH	SECCHI	Summer1	0.900	6.8	POOR	-	-	-
ELIPH	SECCHI	Summer2	0.900	7.4	POOR	-	-	-
ELIPH	DO	Spring1	-	-	-	7.780	-	GOOD
ELIPH	DO	Spring2	-	-	-	6.900	-	GOOD
ELIPH	DO	Summer1	-	-	-	5.405	-	GOOD
ELIPH	DO	Summer2	-	-	-	5.420	-	GOOD

Table 4-28. SAV Season Water quality trends in segment ELIPH (only significant trends are displayed).

Segment	Parameter	Season	Layer	Baseline	Slope	%Change	%BDL	pValue	Direction
ELIPH	TN*	SAV1	S	0.536	0.0210	66.93	0.00	0.0021	DEGRADING
ELIPH	TN*	SAV2	S	0.548	0.0180	57.04	0.00	0.0144	DEGRADING
ELIPH	DIN*	SAV1	S	0.178	0.0070	64.78	0.00	0.0263	DEGRADING
ELIPH	TP*	SAV1	S	0.054	0.0010	44.39	0.00	0.0069	DEGRADING
ELIPH	TSS	SAV2	S	8.00	-0.412	-87.44	0.04	0.0420	IMPROVING
ELIPH	SECCHI	SAV2	S	1.20	-0.01	-15.73	0.00	0.0130	DEGRADING
ELIPH	PLL05	SAV2	S	0.10	0.004	69.70	0.00	0.0380	IMPROVING

Table 4-29. SAV season water quality status in segment ELIPH (value is the median concentration; secchi depth in meters, chlorophyll *a* in µg/l, all other parameters in mg/l).

Segment	Parameter	Value	Score	Status	SAV Goal Value	Habitat Requirement
ELIPH	TN	0.550	71.0	Poor	-	-
ELIPH	DIN	0.163	88.2	Poor	0.1630	Borderline
ELIPH	TP	0.057	91.1	Poor	-	-
ELIPH	DIP	0.022	89.8	Poor	0.0230	Borderline
ELIPH	CHLA	8.22	62.6	Poor	9.1	Pass
ELIPH	TSS	10.00	58.5	Fair	11.8	Pass
ELIPH	SECCHI	0.90	4.9	Poor	-	-
ELIPH	KD	-	-	-	1.60	Fails
ELIPH	PLL05	-	-	-	0.135	Borderline
ELIPH	PLL10	-	-	-	0.061	Fails

Table 4-30. Water quality trends in segment ELIMH (only significant trends are displayed).

Segment	Parameter	Season	Layer	Baseline	Slope	%Change	%BDL	pValue	Direction
ELIMH	TN	Annual	S	0.710	-0.0090	-21.55	0.00	0.0050	IMPROVING
ELIMH	TN	Annual	B	0.611	-0.0077	-21.42	0.00	0.0200	IMPROVING
ELIMH	DIN	Annual	S	0.358	-0.0095	-45.11	2.00	<0.0001	IMPROVING
ELIMH	DIN	Summer1	S	0.386	-0.0096	-42.28	3.80	0.0080	IMPROVING
ELIMH	DIN	Spring2	S	0.270	-0.0085	-53.52	0.00	0.0110	IMPROVING
ELIMH	DIN	Annual	B	0.216	-0.0082	-64.54	0.00	<0.0001	IMPROVING
ELIMH	DIN	Summer1	B	0.289	-0.0073	-42.94	0.00	0.0150	IMPROVING
ELIMH	DIN	Summer2	B	0.373	-0.0087	-39.65	0.00	0.0290	IMPROVING
ELIMH	TP	Annual	S	0.063	-0.0016	-43.17	0.00	<0.0001	IMPROVING
ELIMH	TP	Spring1	S	0.054	-0.0013	-40.93	0.00	0.0210	IMPROVING
ELIMH	TP	Summer1	S	0.104	-0.0014	-22.88	0.00	0.0070	IMPROVING
ELIMH	TP	Summer2	S	0.112	-0.0021	-31.87	0.00	0.0080	IMPROVING
ELIMH	TP	Annual	B	0.069	-0.0013	-32.03	0.00	<0.0001	IMPROVING
ELIMH	TP	Summer2	B	0.120	-0.0029	-41.08	0.00	0.0240	IMPROVING
ELIMH	PO4F	Annual	S	0.038	-0.0010	-45.33	11.10	<0.0001	IMPROVING
ELIMH	PO4F	Spring1	S	0.012	-0.0005	-70.83	17.90	0.0270	IMPROVING
ELIMH	PO4F	Summer1	S	0.070	-0.0019	-46.14	1.90	0.0070	IMPROVING
ELIMH	PO4F	Summer2	S	0.078	-0.0030	-65.38	0.00	0.0180	IMPROVING
ELIMH	PO4F	Annual	B	0.030	-0.0011	-62.33	9.80	<0.0001	IMPROVING
ELIMH	PO4F	Spring1	B	0.016	-0.0006	-65.81	17.90	0.0100	IMPROVING
ELIMH	PO4F	Summer1	B	0.079	-0.0026	-56.31	0.00	<0.0001	IMPROVING
ELIMH	PO4F	Summer2	B	0.085	-0.0032	-64.00	0.00	<0.0001	IMPROVING
ELIMH	CHLA*	Spring1	S	22.70	-1.009	-75.55	0.03	0.0410	IMPROVING
ELIMH	DO	Spring1	B	7.50	0.10	23.66	0.00	0.0090	IMPROVING
ELIMH	DO	Summer1	B	4.10	0.17	71.52	0.00	<0.0001	IMPROVING
ELIMH	SALIN	Annual	S	16.80	0.19	19.45	0.00	0.0010	INCREASING
ELIMH	SALIN	Summer1	S	18.20	0.16	14.73	0.00	0.0480	INCREASING
ELIMH	SALIN	Spring1	B	21.90	-0.41	-31.83	0.00	0.0170	DECREASING
ELIMH	WTEMP	Spring2	S	18.65	0.16	14.13	0.00	0.0220	INCREASING
ELIMH	WTEMP	Annual	B	14.95	0.11	12.01	0.00	0.0160	INCREASING
ELIMH	WTEMP	Spring1	B	11.20	0.30	45.67	0.00	0.0070	INCREASING
ELIMH	WTEMP	Spring1	B	11.20	0.30	45.67	0.00	0.0070	INCREASING
ELIMH	WTEMP	Spring2	B	16.10	0.33	34.51	0.00	0.0020	INCREASING

Table 4-31. Water quality status in segment ELIMH (value is the median concentration, secchi depth in meters, chlorophyll *a* in µg/l, all other parameters in mg/l).

Segment	Parameter	Season	SValue	SScore	SStatus	BValue	BScore	BStatus
ELIMH	TN	Annual	0.650	31.8	GOOD	0.584	24.6	GOOD
ELIMH	TN	Spring1	0.559	11.6	GOOD	0.554	12.0	GOOD
ELIMH	TN	Spring2	0.595	18.3	GOOD	0.566	14.0	GOOD
ELIMH	TN	Summer1	0.718	44.9	FAIR	0.657	38.5	GOOD
ELIMH	TN	Summer2	0.757	52.0	FAIR	0.729	55.0	FAIR
ELIMH	DIN	Annual	0.137	44.7	FAIR	0.132	35.2	GOOD
ELIMH	DIN	Spring1	0.146	23.7	GOOD	0.130	25.5	GOOD
ELIMH	DIN	Spring2	0.146	39.2	GOOD	0.161	39.1	GOOD
ELIMH	DIN	Summer1	0.235	87.6	POOR	0.212	65.1	POOR
ELIMH	DIN	Summer2	0.286	93.3	POOR	0.271	78.6	POOR
ELIMH	TP	Annual	0.050	63.2	POOR	0.057	62.4	POOR
ELIMH	TP	Spring1	0.049	73.9	POOR	0.053	65.6	POOR
ELIMH	TP	Spring2	0.049	67.7	POOR	0.060	70.5	POOR
ELIMH	TP	Summer1	0.080	75.8	POOR	0.077	69.2	POOR
ELIMH	TP	Summer2	0.082	73.7	POOR	0.077	65.0	POOR
ELIMH	DIP	Annual	0.013	85.5	POOR	0.022	87.9	POOR
ELIMH	DIP	Spring1	0.009	86.8	POOR	0.009	86.0	POOR
ELIMH	DIP	Spring2	0.009	83.0	POOR	0.015	89.9	POOR
ELIMH	DIP	Summer1	0.044	96.7	POOR	0.041	87.6	POOR
ELIMH	DIP	Summer2	0.051	96.6	POOR	0.045	86.2	POOR
ELIMH	CHLA	Annual	8.624	44.7	FAIR	-	-	-
ELIMH	CHLA	Spring1	11.036	56.8	FAIR	-	-	-
ELIMH	CHLA	Spring2	11.036	52.1	FAIR	-	-	-
ELIMH	CHLA	Summer1	10.814	41.6	FAIR	-	-	-
ELIMH	CHLA	Summer2	7.009	19.2	GOOD	-	-	-
ELIMH	TSS	Annual	13.340	71.1	POOR	17.610	59.5	POOR
ELIMH	TSS	Spring1	15.625	76.5	POOR	25.250	74.3	POOR
ELIMH	TSS	Spring2	15.500	76.3	POOR	25.250	76.8	POOR
ELIMH	TSS	Summer1	14.570	71.6	POOR	18.729	66.1	POOR
ELIMH	TSS	Summer2	13.380	65.2	POOR	18.425	63.7	POOR
ELIMH	SECCHI	Annual	0.900	25.9	POOR	-	-	-
ELIMH	SECCHI	Spring1	0.700	16.3	POOR	-	-	-
ELIMH	SECCHI	Spring2	0.700	16.5	POOR	-	-	-
ELIMH	SECCHI	Summer1	0.850	30.6	POOR	-	-	-
ELIMH	SECCHI	Summer2	0.900	36.2	POOR	-	-	-
ELIMH	DO	Spring1	-	-	-	8.300	-	GOOD
ELIMH	DO	Spring2	-	-	-	7.280	-	GOOD
ELIMH	DO	Summer1	-	-	-	5.756	-	GOOD
ELIMH	DO	Summer2	-	-	-	5.821	-	GOOD

Table 4-32. SAV Season Water quality trends in segment ELIMH (only significant trends are displayed).

Segment	Parameter	Season	Layer	Baseline	Slope	%Change	%BDL	pValue	Direction
ELIMH	DIN	SAV1	S	0.341	-0.0090	-44.87	2.20	0.0010	IMPROVING
ELIMH	TP	SAV1	S	0.076	-0.0011	-24.61	0.00	0.0020	IMPROVING
ELIMH	PO4F	SAV1	S	0.058	-0.0012	-35.17	4.40	0.0040	IMPROVING
ELIMH	SALIN	SAV1	S	17.15	0.13	13.21	0.00	0.0240	INCREASING
ELIMH	SALIN	SAV1	S	17.15	0.13	13.21	0.00	0.0240	INCREASING

Table 4-33. SAV season water quality status in segment ELIMH (value is the median concentration; secchi depth in meters, chlorophyll *a* in µg/l, all other parameters in mg/l).

Segment	Parameter	Value	Score	Status	SAV Goal Value	Habitat Requirement
ELIMH	TN	0.679	36.9	Good	-	-
ELIMH	DIN	0.209	72.0	Poor	0.2091	Borderline
ELIMH	TP	0.060	67.5	Poor	-	-
ELIMH	DIP	0.018	88.9	Poor	0.0182	Fails
ELIMH	CHLA	8.01	31.4	Good	8.0	Pass
ELIMH	TSS	15.40	75.6	Poor	15.4	Borderline
ELIMH	SECCHI	0.80	22.7	Poor	-	-
ELIMH	KD	-	-	-	1.80	Fails
ELIMH	PLL05	-	-	-	0.095	Fails
ELIMH	PLL10	-	-	-	0.040	Fails

Table 4-34. Water quality trends in segment WBEMH (only significant trends are displayed).

Segment	Parameter	Season	Layer	Baseline	Slope	%Change	%BDL	pValue	Direction
WBEMH	TN	Annual	S	0.800	-0.0176	-37.40	0.00	<0.0001	IMPROVING
WBEMH	TN	Spring1	S	0.893	-0.0232	-44.17	0.00	0.0050	IMPROVING
WBEMH	TN	Summer1	S	0.848	-0.0131	-26.26	0.00	0.0070	IMPROVING
WBEMH	TN	Spring2	S	0.766	-0.0206	-45.72	0.00	0.0020	IMPROVING
WBEMH	TN	Annual	B	0.791	-0.0154	-33.10	0.00	<0.0001	IMPROVING
WBEMH	TN	Spring1	B	0.828	-0.0161	-33.06	0.00	0.0450	IMPROVING
WBEMH	TN	Summer1	B	0.899	-0.0166	-31.39	0.00	0.0200	IMPROVING
WBEMH	TN	Spring2	B	0.828	-0.0215	-44.14	0.00	0.0020	IMPROVING
WBEMH	DIN	Annual	S	0.198	-0.0057	-48.94	2.60	0.0010	IMPROVING
WBEMH	DIN	Summer1	S	0.228	-0.0075	-55.92	0.00	0.0220	IMPROVING
WBEMH	DIN	Annual	B	0.257	-0.0081	-53.58	1.30	0.0010	IMPROVING
WBEMH	DIN	Summer1	B	0.253	-0.0090	-60.47	0.00	0.0380	IMPROVING
WBEMH	DIN	Summer2	B	0.253	-0.0127	-85.34	0.00	0.0490	IMPROVING
WBEMH	TP	Annual	S	0.083	-0.0024	-49.16	0.00	<0.0001	IMPROVING
WBEMH	TP	Spring1	S	0.079	-0.0015	-32.28	0.00	0.0250	IMPROVING
WBEMH	TP	Summer1	S	0.140	-0.0051	-61.93	0.00	<0.0001	IMPROVING
WBEMH	TP	Spring2	S	0.080	-0.0024	-51.00	0.00	0.0040	IMPROVING
WBEMH	TP	Summer2	S	0.141	-0.0051	-61.49	0.00	<0.0001	IMPROVING
WBEMH	TP	Annual	B	0.080	-0.0023	-48.87	0.00	<0.0001	IMPROVING
WBEMH	TP	Summer1	B	0.158	-0.0048	-51.65	0.00	<0.0001	IMPROVING
WBEMH	TP	Spring2	B	0.083	-0.0025	-51.20	0.00	0.0170	IMPROVING
WBEMH	TP	Summer2	B	0.160	-0.0049	-52.06	0.00	0.0060	IMPROVING
WBEMH	PO4F	Annual	S	0.035	-0.0010	-49.28	14.40	<0.0001	IMPROVING
WBEMH	PO4F	Spring1	S	0.010	-0.0005	-85.00	20.50	0.0010	IMPROVING
WBEMH	PO4F	Summer1	S	0.068	-0.0031	-77.50	3.80	<0.0001	IMPROVING
WBEMH	PO4F	Spring2	S	0.026	-0.0009	-58.85	15.40	<0.0001	IMPROVING
WBEMH	PO4F	Summer2	S	0.078	-0.0042	-92.13	0.00	<0.0001	IMPROVING
WBEMH	PO4F	Annual	B	0.033	-0.0012	-61.82	13.70	<0.0001	IMPROVING
WBEMH	PO4F	Spring1	B	0.016	-0.0006	-63.75	23.10	0.0010	IMPROVING
WBEMH	PO4F	Summer1	B	0.072	-0.0033	-78.46	5.80	<0.0001	IMPROVING
WBEMH	PO4F	Spring2	B	0.025	-0.0010	-69.39	17.90	<0.0001	IMPROVING
WBEMH	PO4F	Summer2	B	0.081	-0.0041	-86.58	0.00	<0.0001	IMPROVING
WBEMH	CHLA*	Annual	S	23.00	-0.565	-41.78	0.03	0.0040	IMPROVING
WBEMH	CHLA*	Spring1	S	34.30	-1.544	-76.52	2.60	0.0240	IMPROVING
WBEMH	CHLA*	Summer1	S	25.60	-0.616	-40.89	0.00	0.0340	IMPROVING
WBEMH	CHLA*	Spring2	S	16.20	-0.924	-96.98	2.60	0.0240	IMPROVING
WBEMH	DO	Summer1	B	4.40	0.15	59.69	0.00	0.0030	IMPROVING
WBEMH	SALIN	Annual	S	15.90	0.20	21.27	0.00	0.0030	INCREASING
WBEMH	SALIN	Annual	B	16.70	0.13	13.51	0.00	0.0220	INCREASING

Table 4-35. Water quality status in segment WBEMH (value is the median concentration, secchi depth in meters, chlorophyll *a* in µg/l, all other parameters in mg/l).

Segment	Parameter	Season	SValue	SScore	SStatus	BValue	BScore	BStatus
WBEMH	TN	Annual	0.586	22.9	GOOD	0.628	31.7	GOOD
WBEMH	TN	Spring1	0.569	12.5	GOOD	0.597	16.5	GOOD
WBEMH	TN	Spring2	0.569	15.4	GOOD	0.628	21.9	GOOD
WBEMH	TN	Summer1	0.773	53.7	FAIR	0.810	66.4	POOR
WBEMH	TN	Summer2	0.794	57.7	FAIR	0.826	70.6	POOR
WBEMH	DIN	Annual	0.081	26.1	GOOD	0.116	29.5	GOOD
WBEMH	DIN	Spring1	0.077	9.2	GOOD	0.108	19.2	GOOD
WBEMH	DIN	Spring2	0.075	18.0	GOOD	0.111	24.0	GOOD
WBEMH	DIN	Summer1	0.129	67.2	POOR	0.191	60.7	POOR
WBEMH	DIN	Summer2	0.197	87.4	POOR	0.211	68.2	POOR
WBEMH	TP	Annual	0.057	71.6	POOR	0.056	60.6	POOR
WBEMH	TP	Spring1	0.059	81.8	POOR	0.058	70.7	POOR
WBEMH	TP	Spring2	0.059	77.3	POOR	0.064	74.0	POOR
WBEMH	TP	Summer1	0.096	84.7	POOR	0.109	87.3	POOR
WBEMH	TP	Summer2	0.099	83.4	POOR	0.110	86.6	POOR
WBEMH	DIP	Annual	0.010	78.6	POOR	0.013	73.9	POOR
WBEMH	DIP	Spring1	0.005	58.8	FAIR	0.004	46.3	FAIR
WBEMH	DIP	Spring2	0.005	52.9	FAIR	0.004	37.3	GOOD
WBEMH	DIP	Summer1	0.033	94.6	POOR	0.034	83.9	POOR
WBEMH	DIP	Summer2	0.038	94.5	POOR	0.038	82.6	POOR
WBEMH	CHLA	Annual	11.392	61.2	POOR	-	-	-
WBEMH	CHLA	Spring1	12.816	64.9	POOR	-	-	-
WBEMH	CHLA	Spring2	12.905	61.5	POOR	-	-	-
WBEMH	CHLA	Summer1	15.041	64.9	POOR	-	-	-
WBEMH	CHLA	Summer2	14.774	61.4	POOR	-	-	-
WBEMH	TSS	Annual	21.033	87.2	POOR	25.200	75.6	POOR
WBEMH	TSS	Spring1	29.114	92.9	POOR	34.500	85.0	POOR
WBEMH	TSS	Spring2	26.500	91.6	POOR	34.500	86.3	POOR
WBEMH	TSS	Summer1	28.157	92.8	POOR	34.900	87.3	POOR
WBEMH	TSS	Summer2	31.067	93.9	POOR	41.850	90.7	POOR
WBEMH	SECCHI	Annual	0.600	8.4	POOR	-	-	-
WBEMH	SECCHI	Spring1	0.500	6.7	POOR	-	-	-
WBEMH	SECCHI	Spring2	0.500	6.3	POOR	-	-	-
WBEMH	SECCHI	Summer1	0.500	5.2	POOR	-	-	-
WBEMH	SECCHI	Summer2	0.500	5.2	POOR	-	-	-
WBEMH	DO	Spring1	-	-	-	8.090	-	GOOD
WBEMH	DO	Spring2	-	-	-	7.800	-	GOOD
WBEMH	DO	Summer1	-	-	-	5.723	-	GOOD
WBEMH	DO	Summer2	-	-	-	5.700	-	GOOD

Table 4-36. SAV Season Water quality trends in segment WBEMH (only significant trends are displayed).

Segment	Parameter	Season	Layer	Baseline	Slope	%Change	%BDL	pValue	Direction
WBEMH	TN	SAV1	S	0.813	-0.0161	-33.67	0.00	<0.0001	IMPROVING
WBEMH	DIN	SAV1	S	0.246	-0.0049	-33.86	0.00	0.0120	IMPROVING
WBEMH	TP	SAV1	S	0.110	-0.0032	-49.45	0.00	<0.0001	IMPROVING
WBEMH	PO4F	SAV1	S	0.051	-0.0018	-60.00	6.70	<0.0001	IMPROVING
WBEMH	CHLA*	SAV1	S	19.30	-0.519	-45.75	2.20	0.0250	IMPROVING
WBEMH	CHLA*	SAV1	S	19.30	-0.519	-45.75	0.02	0.0250	IMPROVING
WBEMH	SALIN	SAV1	S	17.15	0.17	16.46	0.00	0.0360	INCREASING
WBEMH	SALIN	SAV1	S	17.15	0.17	16.46	0.00	0.0360	INCREASING

Table 4-37. SAV season water quality status in segment WBEMH (value is the median concentration; secchi depth in meters, chlorophyll *a* in µg/l, all other parameters in mg/l).

Segment	Parameter	Value	Score	Status	SAV Goal Value	Habitat Requirement
WBEMH	TN	0.6976	39.9	Fair	-	-
WBEMH	DIN	0.1414	57.8	Fair	0.1414	Borderline
WBEMH	TP	0.0850	84.5	Poor	-	-
WBEMH	DIP	0.0268	94.1	Poor	0.0268	Borderline
WBEMH	CHLA	12.8160	59.8	Poor	12.8	Borderline
WBEMH	TSS	28.8000	93.3	Poor	28.8	Fails
WBEMH	SECCHI	0.5000	5.3	Poor	-	-
WBEMH	KD	-	-	-	2.90	Fails
WBEMH	PLL05	-	-	-	0.039	Fails
WBEMH	PLL10	-	-	-	0.011	Fails

Table 4-38. Water quality trends in segment SBEMH (only significant trends are displayed).

Segment	Parameter	Season	Layer	Baseline	Slope	%Change	%BDL	pValue	Direction
SBEMH	TN	Annual	S	1.333	-0.0306	-39.02	0.00	<0.0001	IMPROVING
SBEMH	TN	Spring1	S	1.427	-0.0327	-38.96	0.00	0.0030	IMPROVING
SBEMH	TN	Summer1	S	1.294	-0.0241	-31.66	0.00	0.0050	IMPROVING
SBEMH	TN	Spring2	S	1.427	-0.0303	-36.10	0.00	0.0290	IMPROVING
SBEMH	TN	Summer2	S	1.294	-0.0250	-32.84	0.00	0.0060	IMPROVING
SBEMH	TN	Annual	B	1.070	-0.0117	-18.59	0.00	0.0040	IMPROVING
SBEMH	TN	Summer1	B	1.145	-0.0119	-17.67	0.00	0.0050	IMPROVING
SBEMH	TN	Summer2	B	1.239	-0.0123	-16.88	0.00	0.0130	IMPROVING
SBEMH	DIN	Annual	S	0.738	-0.0264	-60.81	0.00	<0.0001	IMPROVING
SBEMH	DIN	Spring1	S	0.726	-0.0159	-37.23	0.00	0.0490	IMPROVING
SBEMH	DIN	Summer1	S	0.714	-0.0219	-52.14	0.00	0.0030	IMPROVING
SBEMH	DIN	Spring2	S	0.726	-0.0195	-45.66	0.00	0.0410	IMPROVING
SBEMH	DIN	Summer2	S	0.714	-0.0219	-52.14	0.00	0.0060	IMPROVING
SBEMH	DIN	Annual	B	0.586	-0.0121	-35.10	0.00	<0.0001	IMPROVING
SBEMH	DIN	Summer1	B	0.661	-0.0141	-36.26	0.00	0.0070	IMPROVING
SBEMH	DIN	Summer2	B	0.721	-0.0134	-31.60	0.00	0.0170	IMPROVING
SBEMH	TP	Annual	S	0.074	-0.0020	-45.95	0.00	<0.0001	IMPROVING
SBEMH	TP	Spring1	S	0.062	-0.0016	-43.87	0.00	0.0020	IMPROVING
SBEMH	TP	Summer1	S	0.107	-0.0022	-34.95	0.00	0.0020	IMPROVING
SBEMH	TP	Spring2	S	0.065	-0.0016	-41.85	0.00	<0.0001	IMPROVING
SBEMH	TP	Summer2	S	0.115	-0.0029	-42.87	0.00	0.0180	IMPROVING
SBEMH	TP	Annual	B	0.079	-0.0024	-51.65	0.00	<0.0001	IMPROVING
SBEMH	TP	Spring1	B	0.068	-0.0019	-47.50	0.00	0.0020	IMPROVING
SBEMH	TP	Summer1	B	0.136	-0.0036	-45.00	0.00	<0.0001	IMPROVING
SBEMH	TP	Spring2	B	0.079	-0.0025	-53.80	0.00	<0.0001	IMPROVING
SBEMH	TP	Summer2	B	0.138	-0.0037	-45.58	0.00	<0.0001	IMPROVING
SBEMH	PO4F	Annual	S	0.048	-0.0014	-49.79	2.00	<0.0001	IMPROVING
SBEMH	PO4F	Summer1	S	0.075	-0.0026	-58.70	0.00	0.0010	IMPROVING
SBEMH	PO4F	Spring2	S	0.038	-0.0012	-53.26	2.60	0.0290	IMPROVING
SBEMH	PO4F	Summer2	S	0.082	-0.0027	-56.32	0.00	0.0050	IMPROVING
SBEMH	PO4F	Annual	B	0.048	-0.0018	-64.02	2.60	<0.0001	IMPROVING
SBEMH	PO4F	Spring1	B	0.032	-0.0012	-63.75	5.10	0.0070	IMPROVING
SBEMH	PO4F	Summer1	B	0.091	-0.0033	-61.65	0.00	<0.0001	IMPROVING
SBEMH	PO4F	Spring2	B	0.041	-0.0019	-79.17	2.60	0.0010	IMPROVING
SBEMH	PO4F	Summer2	B	0.098	-0.0036	-62.58	0.00	0.0010	IMPROVING
SBEMH	CHLA*	Annual	B	3.40	0.075	37.50	0.16	0.0360	DEGRADING
SBEMH	CHLA*	Summer1	B	3.40	0.210	104.90	0.08	0.0200	DEGRADING
SBEMH	CHLA*	Summer2	B	3.40	0.181	90.30	7.70	0.0480	DEGRADING
SBEMH	TSS	Annual	B	13.10	-0.383	-49.74	0.00	0.0100	IMPROVING
SBEMH	TSS	Spring2	B	16.10	-0.675	-71.27	0.00	0.0490	IMPROVING
SBEMH	DO	Spring1	B	5.80	0.13	36.93	0.00	0.0030	IMPROVING
SBEMH	DO	Summer1	B	2.70	0.15	94.44	0.00	0.0010	IMPROVING
SBEMH	SALIN	Annual	S	14.75	0.23	26.80	0.00	0.0010	INCREASING
SBEMH	SALIN	Spring1	S	10.93	0.40	61.46	0.00	0.0320	INCREASING
SBEMH	SALIN	Spring2	S	13.98	0.27	32.99	0.00	0.0180	INCREASING
SBEMH	WTEMP	Annual	S	18.20	0.11	10.40	0.00	0.0100	INCREASING
SBEMH	WTEMP	Spring2	S	20.78	0.22	18.26	0.00	0.0120	INCREASING
SBEMH	WTEMP	Annual	B	17.10	0.25	24.85	0.00	<0.0001	INCREASING
SBEMH	WTEMP	Spring1	B	11.93	0.45	63.92	0.00	<0.0001	INCREASING
SBEMH	WTEMP	Summer1	B	25.50	0.15	10.00	0.00	0.0470	INCREASING
SBEMH	WTEMP	Spring2	B	18.23	0.50	46.57	0.00	<0.0001	INCREASING
SBEMH	PLL05	Annual	S	0.10	0.003	56.10	0.00	0.0150	IMPROVING
SBEMH	PLL05	Summer1	S	0.10	0.004	64.60	0.00	0.0070	IMPROVING
SBEMH	PLL05	Summer2	S	0.10	0.004	59.50	0.00	0.0340	IMPROVING
SBEMH	PLL10	Annual	S	0.00	0.002	.	0.00	0.0360	IMPROVING
SBEMH	PLL10	Summer1	S	0.00	0.002	.	0.00	0.0200	IMPROVING

Table 4-39. Water quality status in segment SBEMH (value is the median concentration, secchi depth in meters, chlorophyll *a* in µg/l, all other parameters in mg/l).

Segment	Parameter	Season	SValue	SScore	SStatus	BValue	BScore	BStatus
SBEMH	TN	Annual	1.026	77.1	POOR	0.875	65.4	POOR
SBEMH	TN	Spring1	0.969	61.8	POOR	0.854	48.5	FAIR
SBEMH	TN	Spring2	0.962	66.6	POOR	0.884	56.6	FAIR
SBEMH	TN	Summer1	0.990	79.9	POOR	0.929	79.3	POOR
SBEMH	TN	Summer2	1.011	82.5	POOR	0.925	80.1	POOR
SBEMH	DIN	Annual	0.437	82.8	POOR	0.373	80.6	POOR
SBEMH	DIN	Spring1	0.419	65.6	POOR	0.363	72.5	POOR
SBEMH	DIN	Spring2	0.419	76.9	POOR	0.363	75.8	POOR
SBEMH	DIN	Summer1	0.444	95.9	POOR	0.405	87.6	POOR
SBEMH	DIN	Summer2	0.444	97.2	POOR	0.435	90.0	POOR
SBEMH	TP	Annual	0.051	67.1	POOR	0.055	61.6	POOR
SBEMH	TP	Spring1	0.046	67.3	POOR	0.050	58.6	POOR
SBEMH	TP	Spring2	0.047	66.2	POOR	0.058	67.9	POOR
SBEMH	TP	Summer1	0.084	78.6	POOR	0.093	82.1	POOR
SBEMH	TP	Summer2	0.090	78.8	POOR	0.102	83.4	POOR
SBEMH	DIP	Annual	0.023	94.6	POOR	0.024	91.1	POOR
SBEMH	DIP	Spring1	0.019	96.0	POOR	0.018	95.9	POOR
SBEMH	DIP	Spring2	0.019	94.7	POOR	0.021	95.4	POOR
SBEMH	DIP	Summer1	0.046	96.3	POOR	0.051	90.7	POOR
SBEMH	DIP	Summer2	0.053	96.7	POOR	0.053	89.5	POOR
SBEMH	CHLA	Annual	3.787	9.3	GOOD	-	-	-
SBEMH	CHLA	Spring1	3.791	10.3	GOOD	-	-	-
SBEMH	CHLA	Spring2	4.432	12.4	GOOD	-	-	-
SBEMH	CHLA	Summer1	8.483	20.9	GOOD	-	-	-
SBEMH	CHLA	Summer2	4.966	11.3	GOOD	-	-	-
SBEMH	TSS	Annual	9.606	48.6	FAIR	12.701	37.6	GOOD
SBEMH	TSS	Spring1	9.510	47.7	FAIR	14.075	31.2	GOOD
SBEMH	TSS	Spring2	10.110	54.5	FAIR	14.480	49.4	FAIR
SBEMH	TSS	Summer1	10.694	54.1	FAIR	14.347	53.5	FAIR
SBEMH	TSS	Summer2	10.350	50.5	FAIR	13.678	51.3	FAIR
SBEMH	SECCHI	Annual	0.975	25.9	POOR	-	-	-
SBEMH	SECCHI	Spring1	0.750	25.8	POOR	-	-	-
SBEMH	SECCHI	Spring2	0.700	16.5	POOR	-	-	-
SBEMH	SECCHI	Summer1	0.925	35.4	POOR	-	-	-
SBEMH	SECCHI	Summer2	0.950	36.2	POOR	-	-	-
SBEMH	DO	Spring1	-	-	-	7.570	-	GOOD
SBEMH	DO	Spring2	-	-	-	6.205	-	GOOD
SBEMH	DO	Summer1	-	-	-	4.539	-	FAIR
SBEMH	DO	Summer2	-	-	-	3.940	-	FAIR

Table 4-40. SAV Season Water quality trends in segment SBEMH (only significant trends are displayed).

Segment	Parameter	Season	Layer	Baseline	Slope	%Change	%BDL	pValue	Direction
SBEMH	TN	SAV1	S	1.266	-0.0240	-32.23	0.00	0.0010	IMPROVING
SBEMH	DIN	SAV1	S	0.702	-0.0209	-50.61	0.00	<0.0001	IMPROVING
SBEMH	TP	SAV1	S	0.100	-0.0019	-32.30	0.00	<0.0001	IMPROVING
SBEMH	PO4F	SAV1	S	0.067	-0.0018	-45.47	1.10	<0.0001	IMPROVING
SBEMH	SALIN	SAV1	S	16.70	0.22	22.59	0.00	0.0080	INCREASING
SBEMH	SALIN	SAV1	S	16.70	0.22	22.59	0.00	0.0080	INCREASING
SBEMH	PLL05	SAV1	S	0.10	0.003	52.70	0.00	0.0150	IMPROVING

Table 4-41. SAV season water quality status in segment SBEMH (value is the median concentration; secchi depth in meters, chlorophyll *a* in µg/l, all other parameters in mg/l).

Segment	Parameter	Value	Score	Status	SAV Goal Value	Habitat Requirement
SBEMH	TN	0.962	77.8	Poor	-	-
SBEMH	DIN	0.419	89.2	Poor	0.4443	Fails
SBEMH	TP	0.063	72.5	Poor	-	-
SBEMH	DIP	0.036	96.3	Poor	0.0356	Fails
SBEMH	CHLA	4.43	10.3	Good	4.6	Pass
SBEMH	TSS	10.35	56.2	Fair	10.2	Pass
SBEMH	SECCHI	0.90	30.9	Poor	-	-
SBEMH	KD	-	-	-	1.60	Fails
SBEMH	PLL05	-	-	-	0.101	Fails
SBEMH	PLL10	-	-	-	0.054	Fails

Table 4-42. Water quality trends in segment EBEMH (only significant trends are displayed).

Segment	Parameter	Season	Layer	Baseline	Slope	%Change	%BDL	pValue	Direction
EBEMH	TN	Annual	S	1.040	-0.0225	-36.78	0.00	<0.0001	IMPROVING
EBEMH	TN	Spring1	S	1.122	-0.0254	-38.48	0.00	0.0200	IMPROVING
EBEMH	TN	Summer1	S	1.107	-0.0162	-24.88	0.00	0.0370	IMPROVING
EBEMH	TN	Spring2	S	0.902	-0.0174	-32.79	0.00	0.0460	IMPROVING
EBEMH	TN	Annual	B	0.855	-0.0190	-37.78	0.00	<0.0001	IMPROVING
EBEMH	TN	Spring1	B	0.762	-0.0052	-11.60	0.00	0.0500	IMPROVING
EBEMH	TN	Summer1	B	1.080	-0.0190	-29.91	0.00	0.0040	IMPROVING
EBEMH	TN	Spring2	B	0.764	-0.0102	-22.70	0.00	0.0040	IMPROVING
EBEMH	DIN	Annual	S	0.507	-0.0172	-57.67	0.00	<0.0001	IMPROVING
EBEMH	DIN	Summer1	S	0.523	-0.0160	-52.01	0.00	0.0050	IMPROVING
EBEMH	DIN	Spring2	S	0.562	-0.0188	-56.87	0.00	0.0200	IMPROVING
EBEMH	DIN	Summer2	S	0.523	-0.0137	-44.53	0.00	0.0340	IMPROVING
EBEMH	DIN	Annual	B	0.490	-0.0179	-62.10	0.00	<0.0001	IMPROVING
EBEMH	DIN	Summer1	B	0.569	-0.0193	-57.66	0.00	<0.0001	IMPROVING
EBEMH	DIN	Summer2	B	0.569	-0.0189	-56.47	0.00	0.0010	IMPROVING
EBEMH	TP	Annual	S	0.075	-0.0022	-49.87	0.00	<0.0001	IMPROVING
EBEMH	TP	Spring1	S	0.067	-0.0023	-58.36	0.00	<0.0001	IMPROVING
EBEMH	TP	Summer1	S	0.113	-0.0023	-34.60	0.00	0.0040	IMPROVING
EBEMH	TP	Spring2	S	0.062	-0.0017	-46.61	0.00	0.0050	IMPROVING
EBEMH	TP	Summer2	S	0.114	-0.0027	-40.26	0.00	0.0070	IMPROVING
EBEMH	TP	Annual	B	0.074	-0.0021	-48.24	0.00	<0.0001	IMPROVING
EBEMH	TP	Spring1	B	0.057	-0.0011	-32.81	0.00	0.0090	IMPROVING
EBEMH	TP	Summer1	B	0.122	-0.0026	-36.23	0.00	<0.0001	IMPROVING
EBEMH	TP	Spring2	B	0.069	-0.0013	-32.03	0.00	0.0100	IMPROVING
EBEMH	TP	Summer2	B	0.125	-0.0027	-36.72	0.00	0.0010	IMPROVING
EBEMH	PO4F	Annual	S	0.044	-0.0011	-42.99	8.70	<0.0001	IMPROVING
EBEMH	PO4F	Summer1	S	0.079	-0.0024	-51.65	0.00	0.0030	IMPROVING
EBEMH	PO4F	Spring2	S	0.041	-0.0016	-66.34	7.70	0.0260	IMPROVING
EBEMH	PO4F	Summer2	S	0.082	-0.0023	-47.98	0.00	0.0310	IMPROVING
EBEMH	PO4F	Annual	B	0.046	-0.0013	-48.57	8.70	<0.0001	IMPROVING
EBEMH	PO4F	Spring1	B	0.027	-0.0007	-44.91	12.80	0.0140	IMPROVING
EBEMH	PO4F	Summer1	B	0.086	-0.0030	-59.30	0.00	<0.0001	IMPROVING
EBEMH	PO4F	Spring2	B	0.041	-0.0016	-67.16	2.60	0.0070	IMPROVING
EBEMH	PO4F	Summer2	B	0.089	-0.0035	-66.85	0.00	0.0010	IMPROVING
EBEMH	DO	Spring1	B	6.70	0.13	32.00	0.00	0.0080	IMPROVING
EBEMH	DO	Spring1	B	6.70	0.13	32.00	0.00	0.0080	IMPROVING
EBEMH	DO	Summer1	B	3.30	0.15	74.80	0.00	0.0050	IMPROVING
EBEMH	DO	Summer1	B	3.30	0.15	74.80	0.00	0.0050	IMPROVING
EBEMH	SALIN	Annual	S	16.85	0.15	15.13	0.00	0.0030	INCREASING
EBEMH	SALIN	Spring1	S	14.05	0.31	37.12	0.00	0.0480	INCREASING
EBEMH	SALIN	Summer1	S	18.20	0.13	12.14	0.00	0.0460	INCREASING
EBEMH	SALIN	Spring2	S	16.30	0.15	15.64	0.00	0.0370	INCREASING
EBEMH	WTEMP	Spring1	B	12.15	0.23	32.73	0.00	0.0100	INCREASING
EBEMH	WTEMP	Spring2	B	18.20	0.29	26.65	0.00	0.0010	INCREASING
EBEMH	PLL05	Annual	S	0.10	0.003	54.40	0.00	0.0040	IMPROVING
EBEMH	PLL05	Summer1	S	0.10	0.003	57.80	0.00	0.0030	IMPROVING
EBEMH	PLL10	Summer1	S	0.00	0.002	.	0.00	0.0250	IMPROVING

Table 4-43. Water quality status in segment EBEMH (value is the median concentration, secchi depth in meters, chlorophyll *a* in µg/l, all other parameters in mg/l).

Segment	Parameter	Season	SValue	SScore	SStatus	BValue	BScore	BStatus
EBEMH	TN	Annual	0.737	44.5	FAIR	0.683	40.9	FAIR
EBEMH	TN	Spring1	0.706	27.6	GOOD	0.704	30.4	GOOD
EBEMH	TN	Spring2	0.723	35.5	GOOD	0.704	33.8	GOOD
EBEMH	TN	Summer1	0.784	55.4	FAIR	0.703	47.6	FAIR
EBEMH	TN	Summer2	0.815	60.6	POOR	0.789	65.0	POOR
EBEMH	DIN	Annual	0.271	70.5	POOR	0.213	59.0	FAIR
EBEMH	DIN	Spring1	0.255	45.6	FAIR	0.236	52.5	FAIR
EBEMH	DIN	Spring2	0.255	61.5	POOR	0.302	68.2	POOR
EBEMH	DIN	Summer1	0.301	91.8	POOR	0.303	79.9	POOR
EBEMH	DIN	Summer2	0.368	95.6	POOR	0.337	85.1	POOR
EBEMH	TP	Annual	0.049	61.7	FAIR	0.053	57.8	FAIR
EBEMH	TP	Spring1	0.043	66.7	POOR	0.048	58.8	POOR
EBEMH	TP	Spring2	0.047	64.3	POOR	0.057	67.6	POOR
EBEMH	TP	Summer1	0.076	72.7	POOR	0.088	77.8	POOR
EBEMH	TP	Summer2	0.087	76.8	POOR	0.094	78.9	POOR
EBEMH	DIP	Annual	0.019	92.2	POOR	0.024	89.2	POOR
EBEMH	DIP	Spring1	0.014	94.4	POOR	0.017	96.8	POOR
EBEMH	DIP	Spring2	0.014	92.4	POOR	0.022	95.6	POOR
EBEMH	DIP	Summer1	0.052	97.6	POOR	0.051	91.0	POOR
EBEMH	DIP	Summer2	0.055	97.0	POOR	0.054	89.2	POOR
EBEMH	CHLA	Annual	6.034	25.6	GOOD	-	-	-
EBEMH	CHLA	Spring1	5.963	24.6	GOOD	-	-	-
EBEMH	CHLA	Spring2	6.622	23.9	GOOD	-	-	-
EBEMH	CHLA	Summer1	9.790	37.4	GOOD	-	-	-
EBEMH	CHLA	Summer2	6.742	19.5	GOOD	-	-	-
EBEMH	TSS	Annual	10.133	57.2	FAIR	14.750	50.3	FAIR
EBEMH	TSS	Spring1	10.820	58.8	POOR	15.375	49.6	FAIR
EBEMH	TSS	Spring2	11.380	61.4	POOR	17.300	60.3	POOR
EBEMH	TSS	Summer1	11.380	58.0	FAIR	19.300	67.5	POOR
EBEMH	TSS	Summer2	11.620	56.8	FAIR	21.283	70.0	POOR
EBEMH	SECCHI	Annual	1.000	33.0	POOR	-	-	-
EBEMH	SECCHI	Spring1	1.100	42.7	FAIR	-	-	-
EBEMH	SECCHI	Spring2	0.800	23.2	POOR	-	-	-
EBEMH	SECCHI	Summer1	0.800	25.7	POOR	-	-	-
EBEMH	SECCHI	Summer2	0.900	36.3	POOR	-	-	-
EBEMH	DO	Spring1	-	-	-	7.940	-	GOOD
EBEMH	DO	Spring2	-	-	-	7.050	-	GOOD
EBEMH	DO	Summer1	-	-	-	4.930	-	FAIR
EBEMH	DO	Summer2	-	-	-	4.590	-	FAIR

Table 4-44. SAV Season Water quality trends in segment EBEMH (only significant trends are displayed).

Segment	Parameter	Season	Layer	Baseline	Slope	%Change	%BDL	pValue	Direction
EBEMH	TN	SAV1	S	1.049	-0.0161	-26.09	0.00	0.0130	IMPROVING
EBEMH	DIN	SAV1	S	0.530	-0.0168	-53.89	0.00	<0.0001	IMPROVING
EBEMH	TP	SAV1	S	0.086	-0.0018	-35.58	0.00	<0.0001	IMPROVING
EBEMH	PO4F	SAV1	S	0.066	-0.0017	-43.79	3.40	0.0020	IMPROVING
EBEMH	SALIN	SAV1	S	17.95	0.14	12.96	0.00	0.0230	INCREASING
EBEMH	SALIN	SAV1	S	17.95	0.14	12.96	0.00	0.0230	INCREASING

Table 4-45. SAV season water quality status in segment EBEMH (value is the median concentration; secchi depth in meters, chlorophyll *a* in µg/l, all other parameters in mg/l).

Segment	Parameter	Value	Score	Status	SAV Goal Value	Habitat Requirement
EBEMH	TN	0.749	48.0	Fair	-	-
EBEMH	DIN	0.301	82.2	Poor	0.3012	Fails
EBEMH	TP	0.070	76.0	Poor	-	-
EBEMH	DIP	0.033	95.8	Poor	0.0327	Fails
EBEMH	CHLA	5.96	18.0	Good	6.0	Pass
EBEMH	TSS	11.27	59.4	Poor	11.3	Pass
EBEMH	SECCHI	0.80	22.7	Poor	-	-
EBEMH	KD	-	-	-	1.80	Borderline
EBEMH	PLL05	-	-	-	0.106	Borderline
EBEMH	PLL10	-	-	-	0.055	Fails

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Glossary of Important Terms

Anoxic - condition in which the water column is characterized by a complete absence of oxygen. Anoxic conditions typically result from excessive decomposition of organic material by bacteria, high respiration by phytoplankton, stratification of the water column due to salinity or temperature effects or a combination of these factors. Anoxic conditions can result in fish kills or localized extinction of benthic communities.

Anthropogenic - resulting from or generated by human activities.

Benthos - refers to organisms that dwell on or within the bottom. Includes both hard substratum habitats (e.g. oyster reefs) and sedimentary habitats (sand and mud bottoms).

B-IBI - the benthic index of biotic integrity of Weisberg et al. (1997). The B-IBI is a multi-metric index that compares the condition of a benthic community to reference conditions.

Biological Nutrient Removal (BNR) - A temperature dependent process in which the ammonia nitrogen present in wastewater is converted by bacteria first to nitrate nitrogen and then to nitrogen gas. This technique is used to reduce the concentration of nitrogen in sewage treatment plant effluents.

Biomass - a quantitative estimate of the total mass of organisms for a particular population or community within a given area at a given time. Biomass for phytoplankton is measured as the total carbon within a liter of water. Biomass for the benthos is measured as the total ash-free dry weight per square meter of sediment habitat.

Chlorophyll *a* - a green pigment found in plant cells that functions as the receptor for energy in the form of sunlight. This energy is used in the production of cellular materials for growth and reproduction in plants. Chlorophyll *a* concentrations are measured in µg/L and are used as estimate of the total biomass of phytoplankton cells in the water column. In general, high levels of chlorophyll *a* concentrations are believed to be indicative of excessive growth of phytoplankton resulting from excess nutrients such as nitrogen and phosphorus in the water column.

Calanoid copepod - crustaceans of the subclass Copepoda and order Calanoida that are the dominant group of the mesozooplankton in marine systems. Copepods in this group (e.g. *Acartia tonsa*) are one of the most important consumers of phytoplankton in estuarine systems.

Chlorophytes - algae belonging to the division Chlorophyta often referred to as true "green algae." Chlorophytes occur in unicellular, colonial and filamentous forms and are generally more common in tidal freshwater and oligohaline portions of estuaries.

Cladocerans - crustaceans of the class Branchipoda and class Cladocera commonly referred to as "water fleas." Although cladocerans are primarily found in tidal freshwater areas in estuaries, blooms of marine cladocerans periodically occur in higher salinity areas. Some smaller species such as *Bosmina longirostris* are believed to be indicators of poor water quality conditions.

Cryptomonads -algae belonging to the division Cryptophyta that have accessory pigments in addition to chlorophyll *a* which give these small flagellated cells a red, brown or yellow color.

Cyanobacteria - algae belonging to the division Cyanophycea that are procaryotic and that occur in single-celled , filamentous and colonial forms. In general, high concentrations of cyanobacteria are considered to be indicative of poor water quality.

Cyclopoid copepod - crustaceans of the subclass Copepoda and order Cyclopoida that are the dominant group of the mesozooplankton in marine systems. Copepods in this group (e.g. *Mesocyclops edax*) are one of the most important consumers of phytoplankton in estuarine systems.

Diatoms - algae belonging to the division Bacillariophyta that have a cell wall that is composed primarily of silica and that consists of two separate halves. Most diatoms are single-celled but some are colonial and filamentous forms. Diatoms are generally considered to be indicative of good water quality and are considered to be appropriate food for many zooplankton.

Dinoflagellates - biflagellated, predominately unicellular protists which are capable of performing photosynthesis. Many dinoflagellates are covered with cellulose plates or with a series of membranes. Some dinoflagellates periodically reproduce in large numbers causing blooms that are often referred to as "red tides." Certain species produce toxins and blooms of these forms have been implicated in fish kills. High concentrations of dinoflagellates are generally considered to be indicative of poor water quality.

Dissolved oxygen (DO) - the concentration of oxygen in solution in the water column, measured in mg/L. Most organisms rely on oxygen for cellular metabolism and as a result low levels of dissolved oxygen adversely affect important living resources such as fish and the benthos. In general, dissolved oxygen levels decrease with increasing pollution.

Dissolved inorganic nitrogen (DIN) - the concentration of inorganic nitrogen compounds including ammonia (NH_4), nitrates (NO_3) and nitrites (NO_2) in the water column measured in mg/L. These dissolved inorganic forms of nitrogen are directly available for uptake by phytoplankton by diffusion without first undergoing the process of decomposition. High concentrations of dissolved inorganic nitrogen can result in excessive growth of phytoplankton which in turn can adversely effect other living resources.

Dissolved inorganic phosphorus (PO4F) - the concentration of inorganic phosphorus compounds consisting primarily of orthophosphates (PO_4), The dissolved inorganic forms of phosphorus are directly available for uptake by phytoplankton by diffusion without first undergoing the process of decomposition. High concentrations of dissolved inorganic phosphorus can result in excessive growth of phytoplankton which in turn can adversely effect other living resources.

Estuary - A semi-enclosed body of water that has a free connection with the open sea and within which seawater is diluted measurably with freshwater derived from land drainage.

Eucaryote - organisms the cells of which have discrete organelles and a nucleus separated from the cytoplasm by a membrane.

Fall-line - location of the maximum upstream extent of tidal influence in an estuary typically characterized by a waterfall.

Fixed Point Stations - stations for long-term trend analysis whose location is unchanged over time.

Flow adjusted concentration (FAC) - concentration value which has been recalculated to remove the variation caused by freshwater flow into a stream. By removing variation caused by flow, the effects of other factors such as nutrient management strategies can be assessed.

Holoplankton - zooplankton such as copepods or cladocerans that spend their entire life cycle within the water column.

Habitat - a local environment that has a community distinct from other such habitat types. For the B-IBI of Chesapeake Bay seven habitat types were defined as combinations of salinity and sedimentary types - tidal freshwater, oligohaline, low mesohaline, high mesohaline sand, high mesohaline mud, polyhaline sand and polyhaline mud.

Hypoxic - condition in which the water column is characterized by dissolved oxygen concentrations less than 2 mg/L but greater than 0 mg/L. Hypoxic conditions typically result from excessive decomposition of organic material by bacteria, high respiration by phytoplankton, stratification of the water column due to salinity or temperature effects or a combination of these factors. Hypoxic conditions can result in fish kills or localized extinction of benthic communities.

Light attenuation (KD) - Absorption, scattering, or reflection of light by dissolved or suspended material in the water column expressed as the change in light extinction per meter of depth. Light attenuation reduces the amount of light available to submerged aquatic vegetation.

Loading - the total mass of contaminant or nutrient added to a stream or river generally expressed in lbs/yr.

Macrobenthos - a size category of benthic organisms that are retained on a mesh of 0.5 mm.

Meroplankton - temporary zooplankton consisting of the larval stages of organisms whose adult stages are not planktonic.

Mesohaline - refers to waters with salinity values ranging between 0.5 and 18.0 ppt.

Mesozooplankton - zooplankton with a maximum dimension ranging between 63 µm and 2000 µm. This size category consists primarily of adults stages of copepods, cladocerans, mysid shrimp, and chaetognaths, as well as, the larval stages of a variety of invertebrates and fish.

Metric - a parameter or measurement of community structure (e.g., abundance, biomass, species diversity).

Microzooplankton - zooplankton with a maximum dimension ranging between 2 µm and 63 µm. This size category consists primarily of single-celled protozoans, rotifers and the larval stages of copepods, cladocerans and other invertebrates.

Nauplii - earliest crustacean larval stage characterized by a single simple eye and three pairs of appendages.

Non-point source - a source of pollution that is distributed widely across the landscape surrounding a water body instead of being at a fixed location (e.g. run-off from residential and agricultural land).

Oligohaline - refers to waters with salinity values ranging between 0.5 and 5.0 ppt.

Oligotrich - protists of the phylum Ciliophora and order Oligotricha. These ciliates are important predators of small phytoplankton in marine systems.

Percent of light at the leaf surface (PLL) - the percentage of light at the surface of the water column that reaches the surface of the leaves of submerged aquatic vegetation generally estimated for depths of 0.5 m and 1.0 m. Without sufficient light at the leaf surface, submerged aquatic plants cannot perform photosynthesis and hence cannot grow or reproduce.

Phytoplankton - that portion of the plankton capable of producing its own food by photosynthesis. Typical members of the phytoplankton include diatoms, dinoflagellates and chlorophytes.

Picoplankton - phytoplankton with a diameter between 0.2 and 2.0 µm in diameter. Picoplankton consists primarily of cyanobacteria and high concentrations of picoplankton are generally considered to be indicative of poor water quality conditions.

Pielou's evenness - an estimate of the distribution of proportional abundances of individual species within a community. Evenness (J) is calculated as follows: $J=H'/\ln S$ where H' is the Shannon - Weiner diversity index and S is the number of species.

Plankton - aquatic organisms that drift within and that are incapable of movement against water currents. Some plankton have limited locomotor ability that allows them to change their vertical position in the water column.

Point source - a source of pollution that is concentrated at a specific location such as the outfall of a sewage treatment plant or factory.

Polyhaline - refers to waters with salinity values ranging between 18.0 and 30 ppt.

Primary productivity - the rate of production of living material through the process of photosynthesis that for phytoplankton is typically expressed in grams of carbon per liter of water per hour. High rates of primary productivity are generally considered to be related to excessive concentrations of nutrients such as nitrogen and phosphorus in the water column.

Probability based sampling - all locations within a stratum have an equal chance of being sampled. Allows estimation of the percent of the stratum meeting or failing the benthic restoration goals.

Procaryote - organisms the cells of which do not have discrete organelles or a nucleus (e.g. Cyanobacteria).

Pycnocline - a rapid change in salinity in the water column indicating stratification of water with depth resulting from either changes in salinity or water temperature.

Random Station - a station selected randomly within a stratum. In every succeeding sampling event new random locations are selected.

Recruitment - The successful dispersal settlement and development of larval forms of plants or animal to a reproducing adult.

Reference condition - the structure of benthic communities at reference sites.

Reference sites - sites determined to be minimally impacted by anthropogenic stress. Conditions at theses sites are considered to represent goals for restoration of impacted benthic communities. Reference sites were selected by Weisberg et al. (1997) as those outside highly developed watersheds, distant from any point-source discharge, with no sediment contaminant effect, with no low dissolved oxygen effect and with a low level of organic matter in the sediment.

Restoration Goal - refers to obtaining an average B-IBI value of 3.0 for a benthic community indicating that values for metrics approximate the reference condition.

Riparian Buffer - An area of trees and shrubs a minium of 100 feet wide located up gradient, adjacent, and parallel to the edge of a water feature which serves to: 1) reduce excess amounts of sediment, organic matter, nutrients, and other pollutants in surface runoff, 2) reduce soluble pollutants in shallow ground water flow, 3) create shade along water bodies to lower aquatic temperatures, 4) provide a source of detritus and large woody debris aquatic organisms, 5) provide riparian habitat and corridors for wildlife, and 6) reduce erosion of streambanks and shorelines

Rotifer - small multicellular planktonic animal of phylum Rotifera. These organisms are a major component of the microzooplankton and are major consumers of phytoplankton. High densities of rotifers are believed to be indicative of high densities of small phytoplankton such as cyanobacteria and as such are believed to be indicative of poor water quality.

Salinity - the concentration of dissolved salts in the water column measured in mg/L, ppt or psu. The composition and distribution of plant and animal communities is directly affected by salinity in estuarine systems. The effects of salinity on living resources must be taken into consideration when interpreting the potential effects of human activities on living resources.

Sarcodinians - single celled protists of the subphylum Sarcodina which includes amoeba and similar forms, characterized by possession of pseudopodia. Planktonic forms of sarcodinians typically have a external shell or test constructed of detrital or sedimentary particles and are important consumers of phytoplankton.

Secchi depth - the depth of light penetration expressed in meters as measured using a secchi disk. Light penetration depth directly affects the growth and recruitment of submerge aquatic vegetation.

Shannon Weiner diversity index - a measure of the number of species within a community and the relative abundances of each species. The Shannon Weiner index is calculated as follows:

$$H' = -\sum_{i=1}^{S} p_i \log_2 p_i$$

where p_i is the proportion of the *i*th species and S is the number of species.

Stratum - a geographic region of unique ecological condition or managerial interest.

Submerged aquatic vegetation (SAV) - rooted vascular plants (e.g. eelgrass, widgeon grass, sago pondweed) that grow in shallow water areas . SAV are important in marine environments because they serve as major food source, provide refuge for juvenile crabs and fish, stabilize sediments preventing shoreline erosion and excessive suspended materials in the water column, and produce oxygen in the water column.

Threshold - a value of a metric that determines the B-IBI scoring. For all metrics except abundance and biomass, two thresholds are used - the lower 5^{th} percentile and the 50^{th} percentile (median) of the distribution of values at reference sites. Samples with metric values less than the lower 5^{th} percentile are scored as a 1. Samples with values between the 5^{th} and 50^{th} metrics are scored as 3 and values greater than the 50^{th} percentile are scored as 5. For abundance and biomass, values below the 5^{th} and above the 95^{th} percentile are scored as 1, values between the 5^{th} and 25^{th} and the 75^{th} and 95^{th} percentiles are scored as 3 and values between the 25^{th} and 75^{th} percentiles are scored as 5.

Tidal freshwater - refers to waters with salinity values ranging between 0 and 0.5 ppt which are located in the upper reaches of the estuary at or just below the maximum upstream extent of tidal influence.

Tintinnid - protists of phylum Ciliophora and order Oligotricha. These ciliates are important predators of small phytoplankton in marine systems. Tintinnids are distinguished from other members of this group because they create an exoskeleton or test made of foreign particles that have been cemented together.

Total nitrogen (TN) - the concentration of both inorganic and organic compounds in the water column which contain nitrogen measured in mg/L. Nitrogen is a required nutrient for protein synthesis. Inorganic forms of nitrogen are directly available for uptake by phytoplankton while organic compounds must first be decomposed by bacteria prior to being available for use for other organisms. High levels of total nitrogen are considered to be detrimental to living resources either as a source of nutrients for excessive phytoplankton growth or as a source of excessive bacterial decomposition that can increase the incidence and extent of anoxic or hypoxic events.

Total phosphorus (TP) - the concentration of both inorganic and organic compounds in the water column which contain phosphorus measured in mg/L. Phosphorus is a required nutrient for cellular metabolism and for the production of cell membranes. Inorganic forms of phosphorus are directly available for uptake by phytoplankton while organic compounds must first be decomposed by bacteria prior to being available for use for other organisms. High levels of total nitrogen are considered to be detrimental to living resources either as a source of nutrients for excessive phytoplankton growth or as a source of excessive bacterial decomposition that can increase the incidence and extent of anoxic or hypoxic events.

Total suspended solids (TSS) - the concentration of suspended particles in the water column, measured in mg/L. The composition of total suspended solids includes both inorganic (fixed) and organic (volatile) compounds. The fixed suspended solids component is comprised of sediment particles while the volatile suspended solids component is comprised of detrital particles and planktonic organisms. The concentration of total suspended solids directly affects water clarity which in turn affects the development and growth of submerged aquatic vegetation.

Zoea - last planktonic larval stage of crustaceans such as crabs and shrimp. Numbers of crab zoea may reflect the recruitment success of adult crabs.

Zooplankton - the animal component of the plankton which typically includes copepods, cladocerans, jellyfish and many other forms.